

PAPERS
OF THE
MICHIGAN ACADEMY OF SCIENCE
ARTS AND LETTERS

XXV (1939)

PART II: ZOÖLOGY

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PART I: BOTANY AND FORESTRY

PART II: ZOÖLOGY

PART III: GEOGRAPHY AND GEOLOGY

PART IV: GENERAL SECTION

ANTHROPOLOGY

LANGUAGE AND LITERATURE

PSYCHOLOGY, SOCIOLOGY

PAPERS OF THE
MICHIGAN ACADEMY OF SCIENCE
ARTS AND LETTERS

EDITORS

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VOLUME XXV (1939)

PART II: ZOÖLOGY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."

— SENECA, *Naturales Quaestiones*

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ZOÖLOGY

THE THOMISIDAE (CRAB SPIDERS) OF MICHIGAN

ARTHUR M. CHICKERING

THE crab spiders acquired their name because, in most species, the body is short, broad, and more or less flattened; the legs usually have a conspicuously crablike position, and locomotion seems to be accomplished as readily sidewise and backward as forward. These spiders spin no definite web for the capture of food but either actively pursue their prey or lie in wait for it protected by their concealing coloration. Most members of the family are drably marked with grays and browns but some are brightly colored to match the flowers within which they lie in ambush. Gabritschewsky (1927) experimentally proved what araneologists have long believed, that such spiders as *Misumena vatia* have the ability to change their colors to correspond rather closely to their background. He showed that immature female spiderlings are incapable of assuming a white or a yellow color when raised on white or yellow paper. On the other hand he found that after the last moult these spiders become very sensitive to reflected light. When adult white females are placed on yellow paper they become yellow in about ten days and change back to white in five or six days when replaced on white paper.

In agreement with my former practice (1939) I have included in this paper only what I consider to be the essential synonymy. In view of the purpose and the probable uses of this series of publications I can see no adequate reason to attempt here a complete summary of the involved synonymy which now exists for many species.

Measurements, color, and other characteristics of the species treated in this paper are defined as stated in my recent article on the Anyphaenidae and Clubionidae of Michigan (1939).

Although changes which may seem somewhat confusing have been recently made in the nomenclature of the Thomisidae only two species treated here have not been reported previously: *Tibellus duttoni* (Hentz) and *Xysticus emertoni* Keyserling.

The figures numbered 16, 17, 21-26, 45, 51-54, 62, 63, 65-68, 71, 72, 74, 75, 79, 82, and 83 were made from specimens in the Museum of Comparative Zoölogy at Harvard College. All others are from specimens in the author's private collection.

It is again a pleasure to express my gratitude for the help of zoölogists and friends: Several years ago in connection with an extensive study of the Thomisidae of the United States Dr. Willis J. Gertsch of the American Museum of Natural History examined and identified the entire accumulation of this family which I then owned. Considerable material has since been added to my collection and changes have been made in the determinations, but I am greatly indebted to Dr. Gertsch for his aid at a time when it was very much needed. On two separate occasions during the past year Mr. Nathan Banks gave me the privilege of working in his laboratory and of studying the extensive collections of Thomisidae in the Museum of Comparative Zoölogy. Miss Elizabeth B. Bryant, of the same museum, helped me repeatedly with numerous valuable suggestions regarding identification and synonymy, together with the loan of many books and reprints absolutely indispensable for the successful pursuit of my studies.

The thirty-one species of Thomisidae now known to occur in Michigan are grouped in two subfamilies as follows:

MISUMENINAE

<i>Coriarachne versicolor</i> Keyserling	<i>X. elegans</i> Keyserling
<i>Misumena vatia</i> (Clerck)	<i>X. emertoni</i> Keyserling
<i>Misumenoides aleatorius</i> (Hentz)	<i>X. ferox</i> (Hentz)
<i>Misumenops asperatus</i> (Hentz)	<i>X. fraternus</i> Banks
<i>M. oblongus</i> (Keyserling)	<i>X. funestus</i> Keyserling
<i>Oxyptila americana</i> Banks	<i>X. graminis</i> Emerton
<i>O. conspurcata</i> Thorell	<i>X. gulosus</i> Keyserling
<i>Tmarus angulatus</i> (Walckenaer)	<i>X. triguttatus</i> Keyserling
<i>Xysticus discursans</i> Keyserling	

PHILODROMINAE

<i>Ebo latithorax</i> Keyserling	<i>P. pernix</i> Blackwall
<i>Philodromus aureolus</i> (Clerck)	<i>P. rufus</i> Walckenaer
<i>P. exilis</i> Banks	<i>P. satullus</i> Keyserling
<i>P. imbecillus</i> Keyserling	<i>Thanatus formicinus</i> (Clerck)
<i>P. infuscatus</i> Keyserling	<i>Tibellus duttoni</i> (Hentz)
<i>P. marxi</i> Keyserling	<i>T. maritimus</i> (Menge)
<i>P. mineri</i> Gertsch	<i>T. oblongus</i> (Walckenaer)

These two subfamilies may be separated by the following key:

1. First and second tarsi not scopulate beneath; third and fourth pairs of legs usually much shorter than first and second pairs; promargin of fang groove without teeth Misumeninae, p. 191
1. First and second tarsi usually scopulate beneath; third and fourth pairs of legs not much shorter than first and second pairs; promargin of fang groove with one or two teeth Philodrominae, p. 217

MISUMENINAE

KEY TO GENERA OF MISUMENINAE

1. Spines rare or lacking except beneath tibiae and metatarsi; body and legs white or yellow, often with crimson or dark stripes or spots (males small and much more highly colored) 2
1. Spines common on body and legs; body and legs usually deeply colored with reddish browns and grays 3
2. A prominent white band connecting the two groups of lateral eyes between the two rows; also a white band and ridge between anterior eyes and ventral margin of clypeus and extending laterally behind eye region
Misumenoides, p. 194
2. No prominent white band connecting the two groups of lateral eyes; no white band and ridge between anterior eyes and ventral margin of clypeus *Misumena*, p. 192
3. Only two pairs of ventral tibial spines on first two pairs of legs; ocular quadrangle slightly longer than wide behind; clavate bristles numerous
Oxyptila, p. 198
3. More than two pairs of ventral tibial spines on first two pairs of legs; ocular quadrangle always wider behind than long; clavate bristles lacking or rare 4
4. Abdomen high and pointed behind; chelicerae porrect; clypeus slanting forward *Tmarus*, p. 201
4. Abdomen either flat or of moderate height and never pointed behind; chelicerae and clypeus vertical 5
5. Posterior median eyes as large as posterior laterals; color usually pale yellow with dull red markings; somewhat hairy in general appearance
Misumenops, p. 195
5. Posterior median eyes always smaller than posterior laterals; color of background always yellowish, with deep reddish brown markings which may become almost black; not so hairy in general appearance 6
6. Cephalothorax strongly depressed and flat; males without definite palpal tarsal tutacula and apophyses *Coriarachne*, p. 192
6. Cephalothorax not strongly depressed, usually quite convex; males with definite palpal tarsal tutacula and apophyses *Xysticus*, p. 202

GENUS CORIARACHNE THORELL, 1870

Coriarachne versicolor Keyserling*Xysticus versicolor* Simon, 1895.*X. versicolor* Petrunkevitch, 1911.*C. versicolor* Comstock, 1913.*Platyxysticus versicolor* Gertsch, 1932.

(Figures 1-3)

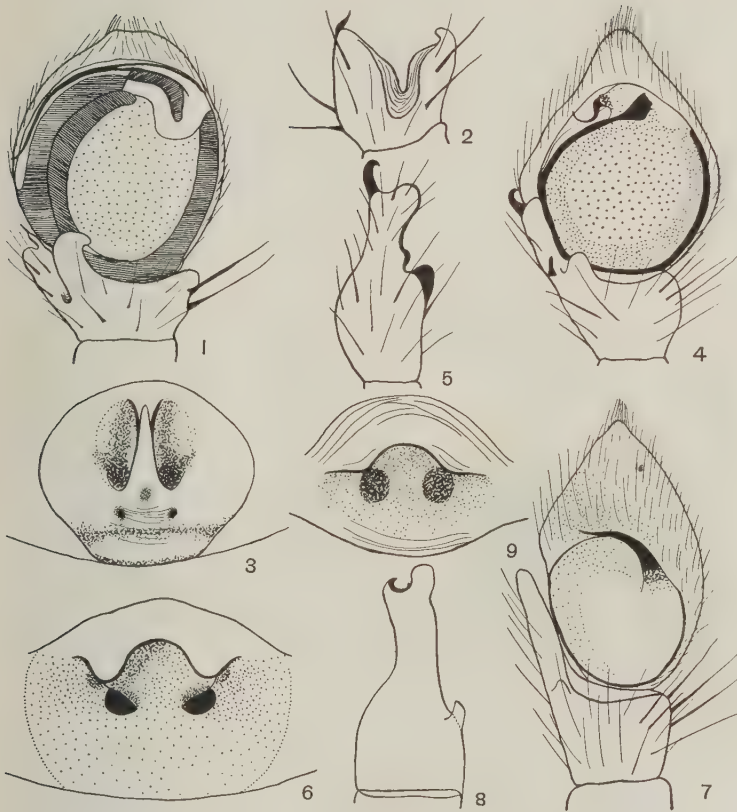
This species closely resembles a *Xysticus* and has frequently been considered a member of that genus, but its features probably distinguish it as a *Coriarachne*. The cephalothorax is strongly depressed, rounded, and very flat; the abdomen, also, is much flattened. In its form the species seems to be well adapted to a life beneath bark, stones, and the like. The color is a highly variable mixture of grays and browns on a yellowish background. Some individuals are so dark as to appear almost black; others are much lighter. Good descriptions of the color have been published by Emerton (1902) and Comstock (1913). The male palp bears two stout tibial apophyses which are nearly equal in size, the dorsal one terminating in a short somewhat bent style (Figs. 1-2). The epigynum (Fig. 3) is a raised area with a convex septum, on each side of which is a shallow cavity. I have both sexes in my collection, and specimens from several localities in the Southern Peninsula and from Marquette in the Northern Peninsula.

GENUS MISUMENA LATREILLE, 1804

Misumena vatia (Clerck)*Araneus vatius* Clerck, 1757.*Thomisus dauci* Hahn, 1831.*T. citreus* Walckenaer, 1837.*T. fartus* Hentz, 1847.*Misumena vatia* Simon, 1875.

(Figures 4-6)

The frequent occurrence of this species on flowers and its bright coloration have helped to make it one of our best-known thomisid spiders. Females are milk-white or bright yellow, usually with a light red, dorsolateral abdominal stripe on each side and a patch of the same color in the region of the central eyes. The red color may



EXTERNAL ANATOMY OF SPIDERS

(Figures 1-9)

1. *Coriarachne versicolor*, male palpus, ventral view
2. *C. versicolor*, tibia, retrolateral view
3. *C. versicolor*, epigynum
4. *Misumena vatia*, male palpus, ventral view
5. *M. vatia*, tibia, retrolateral view
6. *M. vatia*, epigynum
7. *Misumenoides aleatorius*, male palpus, ventral view
8. *M. aleatorius*, tibia, retrolateral view
9. *M. aleatorius*, epigynum

be nearly, or even entirely, lacking. Emerton (1902) and Comstock (1913) have furnished good figures of the color and form of the female of this species. Males usually have the first two pairs of legs all red except the tarsi, which are partly yellowish. The last two pairs of legs are yellowish or white. The cephalothorax is reddish and ordinarily has a central light stripe about as wide as the distance between the anterior lateral eyes. There are two lateral and two dorsal abdominal reddish stripes, the latter more or less broken into spots. Spines are rare except beneath the tibiae and the metatarsi of the first two pairs of legs. Females sometimes reach a length of 12 mm. or even more, but those in my collection average about 8 mm. when mature. Males, however, are only about 3 mm. long and are much slenderer with proportionately longer legs. The male palp (Figs. 4-5) has two lateral tibial apophyses, the ventral one being short and blunt whereas the dorsal one is long and stout and terminates in a prominent hook. The epigynum (Fig. 6) is a raised, somewhat dome-shaped structure. There is a transverse shelf with two lobes pointing backward, and posterior to each of these lies an aperture, partly beneath an obscure fold. This species is widely distributed over North America and Europe, and I have collected it from many localities in both peninsulas of Michigan.

GENUS MISUMENOIDES F. CAMBRIDGE, 1900

Misumenoides aleatorius (Hentz)

Thomisus aleatorius Hentz, 1847.

Runcinia brendelii Keyserling, 1880.

R. aleatoria Banks, 1892.

Misumena aleatoria Emerton, 1892.

(Figures 7-9)

This species resembles *Misumena vatia* to some extent and may at times be mistaken for it. Most commonly the females are white or yellow without markings, but sometimes they have dark spots or stripes where the crimson stripes occur in *M. vatia*. They may also have dark spots elsewhere on the abdomen and legs. In life the males have a bright green cephalothorax, often with brown along the sides; the abdomen is bright yellow. The first two pairs of legs are dark brown and the others are light-colored. The females in my

collection average only about 5.5 mm. long, but individuals often reach a length of 8 or 9 mm. The males are about 3 mm. long and proportionately longer-legged. This is another species which frequents flowers. It is widely distributed over the whole of the United States and most of Canada, but it does not seem to be a common species in Michigan. I have both sexes in my collection, however, taken from a few localities in the southern part of the state. Other than the features of the external genitalia the most distinguishing characteristic is the presence of a white line connecting the lateral eyes of each side and extending between the two rows of eyes. There is also a white line on a low ridge extending along the ventral margin of the clypeus and laterally on both sides considerably posterior to the eye region. The epigynum (Fig. 9) is somewhat like that of *M. vatia* but is less complicated. The male palp (Figs. 7-8) is provided with two lateral tibial apophyses, the ventral one being reduced to a small spur; the dorsal one is long, stout, and provided distally with a blunt process and a sharp hook.

GENUS MISUMENOPS F. CAMBRIDGE, 1900

There is some doubt regarding the validity of this genus, and Cambridge admitted when he established it that it was a "genus of convenience." It is closely related to *Misumena* but can be distinguished from it by the following features: The spines on the legs and body are more numerous; the lateral eyes are more closely connected by a rounded ridge; the anterior row of eyes is less strongly recurved, and the posterior row more strongly recurved. Two species appear in my collection; they may be separated by the following key:

KEY TO THE SPECIES OF *MISUMENOPS*

MALES

1. Palpal tarsal embolus extended retrolaterally, where it describes almost a complete circle; dorsal lateral tibial apophysis elongated and extended parallel to tarsus for about one fourth the length of the latter; cephalothorax usually with two dorsolateral reddish stripes
M. asperatus, p. 196
1. Palpal tarsal embolus not extended retrolaterally; dorsal lateral palpal tibial apophysis not elongated and extended parallel to tarsus; cephalothorax usually without conspicuous reddish markings
M. oblongus, p. 197

FEMALES

1. Numerous spines and bristles on body and legs; typically pale yellow with dull red markings; epigynum with a prominent cavity separated within into two smaller cavities by a central septum . . . *M. asperatus*, p. 196
1. Fewer spines and bristles on body and legs; typically pale yellow or white with few or no red markings; epigynum with an obscure central lobe, on each side of which is a curved tube and behind which are two shallow cavities *M. oblongus*, p. 197

Misumenops asperatus (Hentz)

Thomisus asperatus Hentz, 1847.

Misumena rosea Keyserling, 1880.

M. foliata Banks, 1892.

M. placida Banks, 1892.

M. asperata Emerton, 1892.

Misumessus asperatus Banks, 1907.

M. asperatus Comstock, 1913.

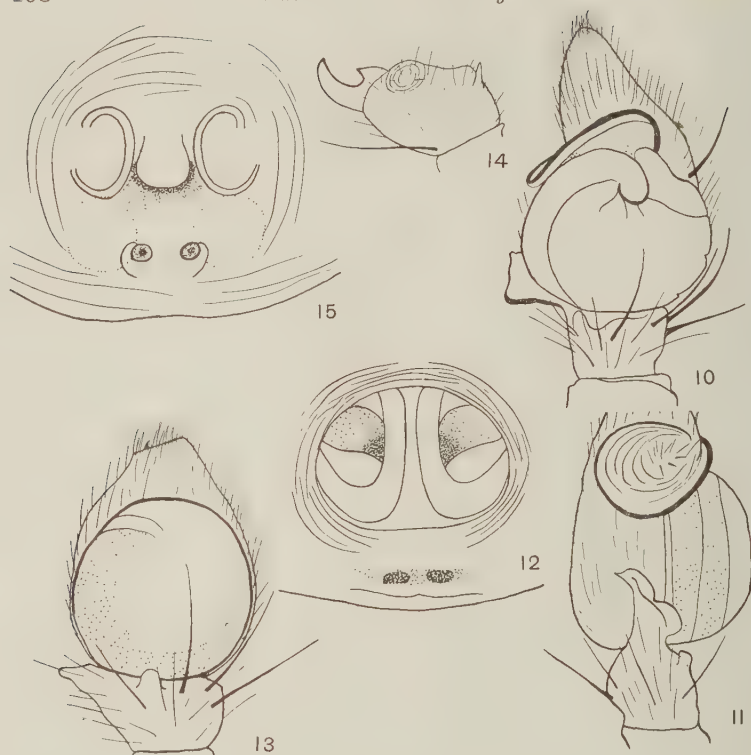
(Figures 10-12)

This is a species with a wide distribution through the United States east of the Rocky Mountains, through Canada, Mexico, much of Central America, and the West Indies. It is a very common species in Michigan and often is abundant in open fields. I have numerous specimens of both sexes from many localities in the Southern Peninsula but no specimens from the Northern Peninsula. Females are about 6 or 7 mm. long and are usually pale yellow, with dull reddish markings which are frequently lost in alcoholic preservation. Two dorsolateral cephalothoracic reddish brown stripes generally occur. There is a central basal abdominal stripe and two lateral stripes. Behind the central stripe is a double series of spots on the posterior half of the abdomen. The underparts are yellowish. Frequently the legs are spotted with reddish brown. Males are about 3.5 to 4 mm. long. They have the same color markings as females but the colors are brighter and cover more area. The male palp is very distinctive in having a much-twisted embolus which extends retrolaterally and there makes almost a complete circle within a depression in the cymbium (Figs. 10-11). Of the two lateral palpal tibial apophyses the ventral one is reduced to a short blunt process, whereas the dorsal one is long, stout, and irregular distally. The epigynum (Fig. 12) consists of a rather conspicuous cavity within which are two smaller cavities separated by a central septum.

Misumenops oblongus (Keyserling)*Misumena oblonga* Keyserling, 1880.*Misumessus oblongus* Banks, 1904.

(Figures 13-15)

Misumenops oblongus is known from a large part of the United States east of the Rocky Mountains and from the Southwest, but it seems to occur in Michigan much less frequently than does *M. asperatus*. I have several mature males from different localities in the Southern Peninsula but only one mature female. So far as I know the species has not been collected in the Northern Peninsula. The females from the Southern Peninsula are less spiny and have fewer bristles than has *M. asperatus*. They are usually without distinct color markings. The abdomen is a glistening white, the other parts yellowish. All my specimens were taken from weeds and flowers, where they may be confused with *M. vatia*. They are about 5 mm. long. Males are well supplied with erect spines, which tend to be arranged in rather definite rows. The yellowish cephalothorax has a narrow red margin. Numerous glistening white patches and a central double row of reddish spots appear on the yellowish abdomen. Red spots may also occur in other parts of the body, and the anterior spinnerets and the postabdomen are ordinarily red. There is likewise a good deal of red on the legs, which is usually distributed as follows: The first two pairs of femora are red distally and each has a row of prolateral red spots; the patellae are red distally; the tibiae are red both distally and proximally; the metatarsi and tarsi are red for the distal half or two thirds. The other two pairs of legs are yellowish except for a few isolated spots. The males are about 2.5 mm. long. The most distinctive feature of the male palp is the very wide tibia. There are two tibial apophyses, the ventral one reduced to a short blunt process, the dorsal one extending laterally and terminating in a characteristic hook (Figs. 13-14). The epigynum (Fig. 15) is distinctive because it has a central lobe with an obscure curved tube on either side of it. The two dotted areas behind the lobe may be shallow depressions. They show as such on some of the specimens in the Museum of Comparative Zoölogy. Still further posteriorly there are two small apertures about 1.5 diameters apart.



EXTERNAL ANATOMY OF SPIDERS

(Figures 10-15)

- 10. *Misumenops asperatus*, male palpus, ventral view
- 11. *M. asperatus*, tibia and base of tarsus, retrolateral view
- 12. *M. asperatus*, epigynum
- 13. *Misumenops oblongus*, male palpus, ventral view
- 14. *M. oblongus*, tibia, retrolateral view
- 15. *M. oblongus*, epigynum

GENUS OXYPTILA SIMON, 1864

A good revision of this genus based upon the material in the Museum of Comparative Zoölogy was published in 1930 by Miss Elizabeth Bryant. Nine species were recognized at that time and

more have been described since. Only two of these are known to me from Michigan. They are small, inconspicuously marked, and apparently live on the ground among dead leaves and other débris from which they may be sifted. Such facts may account for their uncommon occurrence in museum collections. The median ocular quadrangle is slightly longer than wide behind and usually has parallel sides. Both rows of eyes are recurved, the posterior medians being much smaller than the posterior laterals and farther from them than from one another. The tibiae of the first two pairs of legs each bear two pairs of ventral spines and the corresponding metatarsi each bear three pairs. The presence of numerous clavate bristles is also a good generic character and their distribution may have specific value. The dark reddish brown color patterns are so variable that they are unreliable for purposes of identification. The characters of the male palp make it easy to place the males of our species, but the epigyna seem to be so variable that they are less trustworthy than usual. The prominent anterior lobe or "peg" appears to be a good generic feature in all females.

KEY TO THE SPECIES OF *OXYPTILA*

MALES

1. Dorsal palpal tibial apophysis reaches to about middle of tarsus; ventral palpal tibial apophysis expanded distally; tip of embolus somewhat flattened *O. americana*, p. 199
1. Dorsal palpal tibial apophysis reaches well beyond middle of tarsus; ventral palpal tibial apophysis blunt but not expanded distally; tip of embolus not flattened *O. conspurcata*, p. 201

FEMALES

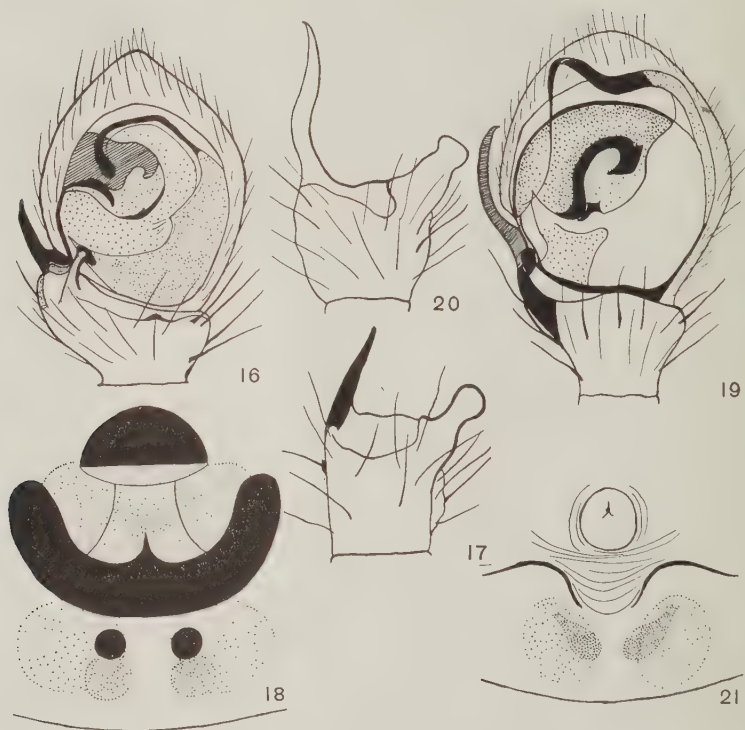
1. Epigynum with a broad U-shaped procurved ridge; tip of median epigynal "peg" hemispherical as seen from below *O. americana*, p. 199
1. Epigynum with a pair of mildly developed ridges not united medially; tip of median epigynal "peg" not hemispherical as seen from below
O. conspurcata, p. 201

Oxyptila americana Banks

O. conspurcata Emerton, 1894 (in part).

(Figures 16-18)

Only females of the species have been taken by me in Michigan but I have this sex from both peninsulas. The species is probably a typical northern one. Females have a median light-colored cephalo-



EXTERNAL ANATOMY OF SPIDERS

(Figures 16-21)

- 16. *Oxyptila americana*, male palpus, ventral view
- 17. *O. americana*, tibia, retrolateral view
- 18. *O. americana*, epigynum
- 19. *Oxyptila conspurcata*, male palpus, ventral view
- 20. *O. conspurcata*, tibia, retrolateral view
- 21. *O. conspurcata*, epigynum

thoracic stripe with a brown stripe on each side of it and a dark irregular margin. There is a little cream color between the rows of eyes. The abdomen is covered with brown spots and cream-colored stripes. The sternum and coxae are light brown, with the venter mottled with brown. The legs are generally brown. Females are about 4 mm. long and males about 3 mm. When it is typically

developed the epigynum (Fig. 18) is a broad U-shaped transverse fold partly enclosing a prominent cavity. Anterior to the fold is the conspicuous median "peg," the tip of which is hemispherical when viewed from below. Posterior to the fold are two small circular spots about 1.5 diameters apart. Males are colored much like the females. Of the two lateral tibial palpal apophyses (Figs. 16-17) the dorsal one is slender, pointed, and reaches to about the middle of the tarsus; the ventral one is shorter and expanded distally. The tip of the embolus is somewhat flattened.

Oxyptila conspurcata Thorell

O. georgiana Keyserling, 1880.

O. conspurcata Emerton, 1894 (in part).

(Figures 19-21)

This species is represented in my collection by a single male about 3 mm. long. Females in the Museum of Comparative Zoölogy are about 4 mm. long. The cephalothorax of my male specimen is brown, with a median light stripe and an irregular dark spot on each side of it. The abdomen is generally cream-colored above and has two pairs of elongated dark spots near the center. The sternum and coxae are light and the venter is light with dark spots. The male palp has two lateral tibial apophyses (Figs. 19-20), the dorsal one being long, slender, and extended well beyond the middle of the tarsus, whereas the ventral one is shorter and blunt at its distal end. The epigynum (Fig. 21) shows a pair of mildly developed folds not meeting ventrally. Anterior to these folds is the usual "peg," which is not hemispherical when viewed from below, and posterior to them are two elongated spots less than a diameter apart.

GENUS TMARUS SIMON, 1875

Tmarus angulatus (Walckenaer)

Thomisus angulatus Walckenaer, 1837.

T. caudatus Hentz, 1847.

Tmarus rubromaculatus Keyserling, 1880.

T. caudatus Emerton, 1892.

T. angulatus Comstock, 1913.

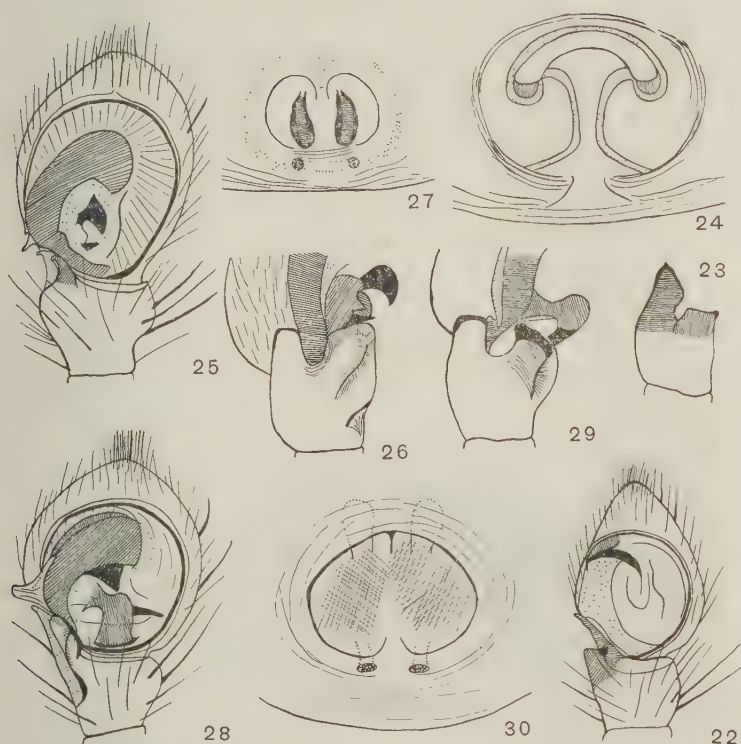
(Figures 22-24)

Tmarus angulatus is our only northern member of a genus which has many species in tropical regions. Several are known from the

southern states and Gertsch (1936) has recently described a new one from Texas. *T. angulatus* is easily identified because its abdomen is high and pointed behind, although this characteristic is less pronounced in the males. Emerton's (1902) and Comstock's (1913) figures are useful to show the form and the distinctive features. It will be noted that the body in *Tmarus* is more elongated than in any other of our Michigan Misumeninae. When at rest upon plants, where they most commonly occur, these spiders "hunch" themselves into a compact form, which, together with their protective coloration, gives them a certain measure of security. The clypeus slants forward instead of being vertical as in most of our Thomisidae. The chelicerae are quite porrect. Males are about 5 mm. long; females are somewhat larger and may reach a length of 8 mm. The cephalothorax and abdomen show a mixture of dull grays, browns, and reds. An irregular light central patch occurs on the cephalothorax just behind the middle, and from this light patch three white lines usually radiate to the eye region and others extend laterally and posteriorly. The legs are much spotted with dark brown. The underparts are all light-colored but they are sometimes spotted a little with dark colors. The epigynum (Fig. 24) has a shallow crescentic recurved groove surrounded by a series of tubes showing through from within, the whole making a rather complicated design. The most characteristic feature of the male palpus (Figs. 22-23) is the presence of two lateral apophyses, the ventral one being short, and angular at its distal end, and the dorsal one being more than twice as long and pointed distally.

GENUS XYSTICUS C. KOCH, 1835

More than half of all our Michigan Misumeninae belong to this interesting genus, which includes more species than any other genus in the Thomisidae. Thirty-two species were listed from France by Berland and Fage (Simon, 1932), and Comstock (1913) stated that about forty species were known from the United States alone. Petrunkevitch (1911) listed about fifty from the whole Western Hemisphere. Many new species have been described during the past ten or fifteen years by Bryant (1930, 1933), Chamberlin (1925, 1929), and Gertsch (1933, 1934). In recent years much synonymizing and revision have been carried out. Gertsch (1934 and in unpublished



EXTERNAL ANATOMY OF SPIDERS

(Figures 22-30)

- 22. *Tmarus angulatus*, male palpus, ventral view
- 23. *T. angulatus*, tibia, retrolateral view
- 24. *T. angulatus*, epigynum
- 25. *Xysticus discursans*, male palpus, ventral view
- 26. *X. discursans*, tibia and base of tarsus, retrolateral view
- 27. *X. discursans*, epigynum
- 28. *Xysticus elegans*, male palpus, ventral view
- 29. *X. elegans*, tibia and base of tarsus, retrolateral view
- 30. *X. elegans*, epigynum

material) has made a very careful study of this genus in his extensive treatment of the Thomisidae. I am depending largely upon his decisions for the synonyms recognized in this paper, although I have

personally checked each species and made careful examinations of many individuals in the collections of the Museum of Comparative Zoölogy. It is probably safe to state that there are now more than fifty known species in the United States. *Xysticus* is a typical temperate-zone genus, only a few species being known from tropical and subtropical regions. In her recent extensive study of Cuban spiders Miss Elizabeth Bryant found only one *Xysticus*, and this is soon to be described as a new species. The colors in the genus are usually various shades of grays and browns arranged in spots, bands, and streaks, all more or less mixed with yellowish spots and streaks. These spiders live on herbs, low bushes, fences, the bark of trees, and the like. Frequently they can be found beneath stones, boards, dead bark, and brush. The median ocular quadrangle is almost as wide in front as behind, and a little wider than long. The anterior median eyes are much smaller than the anterior laterals and farther from one another than from the anterior laterals. The posterior median eyes are also smaller than the posterior laterals but closer to one another than to the posterior laterals. The anterior row of eyes is gently recurved, the posterior row strongly recurved. The tibiae and the metatarsi of the first two pairs of legs usually have more than three pairs of ventral spines apiece, and the tarsal claws each have five or six teeth. The body and legs are well supplied with spines and simple bristles but never have clavate bristles. The palpus of the male always bears a tutaculum on the retrolateral side of the cymbium for the reception of the tip of the embolus. Two more or less well developed tarsal apophyses always occur and are of great importance in determining species.

KEY TO THE SPECIES OF *XYSTICUS*

MALES

- Palpal bulb with a long flat plate extending across its face (Fig. 37); the two palpal tibial apophyses nearly equal in size and similar in form; anterior tarsal apophysis obscure, posterior apophysis a long slender rod extending obliquely across bulb *X. fraternus*, p. 211
1. Features of palpal bulb and tibial apophyses not as above 2
 2. Palpal tarsal apophyses enlarged and elongated transversely across bulb, length of posterior apophysis nearly equal to width of bulb (Fig. 31); two tibial apophyses very unequal in length, dorsal one half the length of tarsus *X. emertoni*, p. 208
 2. Features of tarsal and tibial apophyses not as above 3

3. Palpal tarsal apophyses generally reduced in size, anterior one beaklike (Figs. 25-26) and turned toward the tibia, posterior one small, directed medially; dorsal lateral tibial apophysis simple and blunt distally, ventral apophysis deeply excavated *X. discursans*, p. 206
3. Features of palpal tarsal and tibial apophyses not as above 4
4. Palpal tarsal apophyses (Figs. 28-29) originate close together, massive posterior one expanded distally and turned toward tibia, slender anterior one turned medially; dorsal lateral palpal tibial apophysis a simple obtuse process, ventral apophysis folded and intricately excavated distally *X. elegans*, p. 207
4. Features of palpal tarsal and tibial apophyses not as above 5
5. Palpal tarsal apophyses (Fig. 40) slender and more or less twisted about one another; dorsal lateral tibial apophysis a simple bladeliike process, ventral apophysis extended distally into an oblique beaklike extension *X. funestus*, p. 212
5. Features of palpal tarsal and tibial apophyses not as above 6
6. Anterior palpal tarsal apophysis attached near its middle and obliquely elongated (Figs. 34, 43) 7
6. Anterior palpal tarsal apophysis not attached near its middle and obliquely elongated 8
7. Anterior palpal tarsal apophysis about one third as long as tarsus and meets the posterior apophysis, which is slender, free, and elongated (Figs. 43-44); ventral lateral tibial apophysis simple, distal end turned medially *X. graminis*, p. 213
7. Anterior palpal tarsal apophysis (Figs. 34-35) much less than one third as long as tarsus and does not meet posterior apophysis, which is not slender, free, and elongated *X. ferox*, p. 210
8. Palpal tarsal apophyses larger, turned medially toward each other (Figs. 49-50); dorsal lateral tibial apophysis narrowed to a point distally, ventral apophysis extended into an oblique beaklike organ distally *X. triguttatus*, p. 216
8. Palpal tarsal apophyses smaller, turned toward tibia and, less distinctly, toward each other (Figs. 46-47); dorsal lateral tibial apophysis not pointed distally and ventral apophysis not extended into an oblique beaklike organ *X. gulosus*, p. 214

FEMALES

1. Epigynum with a pair of more or less prominent central longitudinal folds (ridges) 2
1. Epigynum without central longitudinal folds 6
2. Main part of epigynum nearly as long as broad, enclosing two prominent longitudinal ovoid bodies (folds) situated close together (Fig. 48) *X. gulosus*, p. 214
2. Main part of epigynum much broader than long and without such ovoid bodies as above 3
3. Main part of epigynum about twice as broad as long, with longitudinal folds farther apart and essentially parallel or slightly diverging posteriorly (Fig. 45) *X. graminis*, p. 213
3. Main portion of epigynum much less than twice as broad as long, with longitudinal folds closer together and converging posteriorly to some extent 4

4. A larger species; longitudinal epigynal folds attached closer to anterior rim and less elevated (Fig. 42) *X. funestus*, p. 212
4. Smaller species; longitudinal epigynal folds not attached so closely to anterior rim and much more elevated 5
5. Longitudinal epigynal folds more massive, less of a channel between them, somewhat farther apart (Fig. 27); a somewhat larger species not notably whitish dorsally on abdomen; spermathecae more than three diameters apart *X. discursans*, p. 206
5. Longitudinal epigynal folds less massive (thin plates), more of an enclosed channel between them, somewhat closer together (Fig. 51); a smaller species with a whitish abdomen dorsally; spermathecae only about a diameter of one of them apart *X. triguttatus*, p. 216
6. Depressed region of the epigynum distinctly divided into a deeper anterior part and a shallower posterior part (Fig. 33); spermathecae included within the main area and less than one diameter apart
X. emertoni, p. 208
6. Main part of the epigynum not distinctly divided into a deeper anterior part and a shallower posterior part; spermathecae not included in the main area 7
7. Excavated portion of the epigynum distinctly subdivided into two smaller lateral depressions separated by a broad low septum (Fig. 39)
X. fraternus, p. 211
7. Excavated portion of the epigynum not subdivided into two smaller lateral depressions by a broad low septum 8
8. Excavated part of the epigynum indistinctly separated into two parts by a low narrow central septum; no tubes visible from within (Fig. 30)
X. elegans, p. 207
8. Excavated part of the epigynum not divided into separate divisions by a central septum; several tubes showing from within (Fig. 36)
X. ferox, p. 210

Xysticus discursans Keyserling

Oxyptila cinerea Emerton, 1892.

X. vernalis Bryant, 1930.

X. canadensis Gertsch, 1934 (new name).

(Figures 25-27)

Xysticus discursans is now known from many localities from Nova Scotia across the continent to California and Alaska and, in the east, as far south as Alabama. I have only two mature females to represent the species from Michigan, both collected in the vicinity of Albion. Females are 5.5 mm. long and males about 3.5 mm. In females the cephalothorax and the legs are light brown, much spotted and striped with dark brown or black. There is a light central cephalothoracic stripe about as wide as the eye group and a black spot just where the posterior declivity begins. The abdomen is light

gray dorsally with black bars across the posterior end. The epigynum (Fig. 27) is mildly excavated, considerably wider than long, and has a pair of prominent folds which are distinctly swollen posteriorly and about as far apart as the greatest diameter of one of them. The spermathecae are small and separated from one another by about three times the diameter of one of them. In this species the tibiae of the first two pairs of legs are said to bear four pairs of ventral spines, and the corresponding metatarsi three pairs; but, since I have noticed several discrepancies, I think there must be considerable variation in this character. Miss Bryant (1930) has published a good description of the male. Its markings are more vivid than those of the female but otherwise the coloration is very similar. The male palpus (Figs. 25-26) has two tarsal apophyses, the anterior one being a stout beaklike structure and the posterior one a shorter, slenderer tooth. The more dorsal of the two tibial apophyses ends in an obtuse recurved edge; the ventral apophysis is more massive and is quite deeply excavated retrolaterally. Miss Bryant kindly called my attention to the fact that *Oxyptila cinerea* Emerton is a synonym for *X. discursans* Keyserling; I have confirmed this by examination of Emerton's type.

Xysticus elegans Keyserling

X. limbatus Keyserling, 1880 (female).

X. limbatus Emerton, 1892.

X. elegans Comstock, 1913 (male).

X. elegans Gertsch, 1934.

(Figures 28-30)

This is one of our largest *Xysticus* and the most common in Michigan. Males are about 5.5 mm. long, females 7.5 to 8 mm. Males are quite striking because of their strongly contrasting colors. A broad light stripe bordered on each side with a yellow line runs through the center of the cephalothorax, and a yellow transverse line also occurs between the two rows of eyes. Dorsally the abdomen is divided into four pairs of large brown patches separated by cream-colored stripes and crossbands. The cephalothoracic colors of the female are like those of the male, but the abdomen lacks the distinct brown patches. Instead it has indefinite dark areas outlined faintly and brokenly with cream-colored lines. The underparts are much lighter and are closely spotted with small brown dots. The species is known

from several localities in eastern Canada, in New England, southward to Alabama, and westward as far as Colorado. My collection contains numerous examples of the two sexes from both Michigan peninsulas. The epigynum (Fig. 30) contains a prominent cavity indistinctly separated into lateral halves by a low central septum. The spermathecae are oval and separated from one another by a little less than the length of one of them. The male palpus (Figs. 28-29) possesses a pair of tarsal apophyses very unequal in size and dissimilar in shape. They arise close together but quickly diverge. The larger apophysis is stout, expanded distally, and turned at a right angle toward the tibia. The smaller apophysis is a slender spike which projects toward the prolateral side of the tarsus. The dorsal lateral tibial apophysis is a simple, obtuse, and somewhat recurved process; the ventral apophysis is more or less intricately excavated distally.

Xysticus emertoni Keyserling

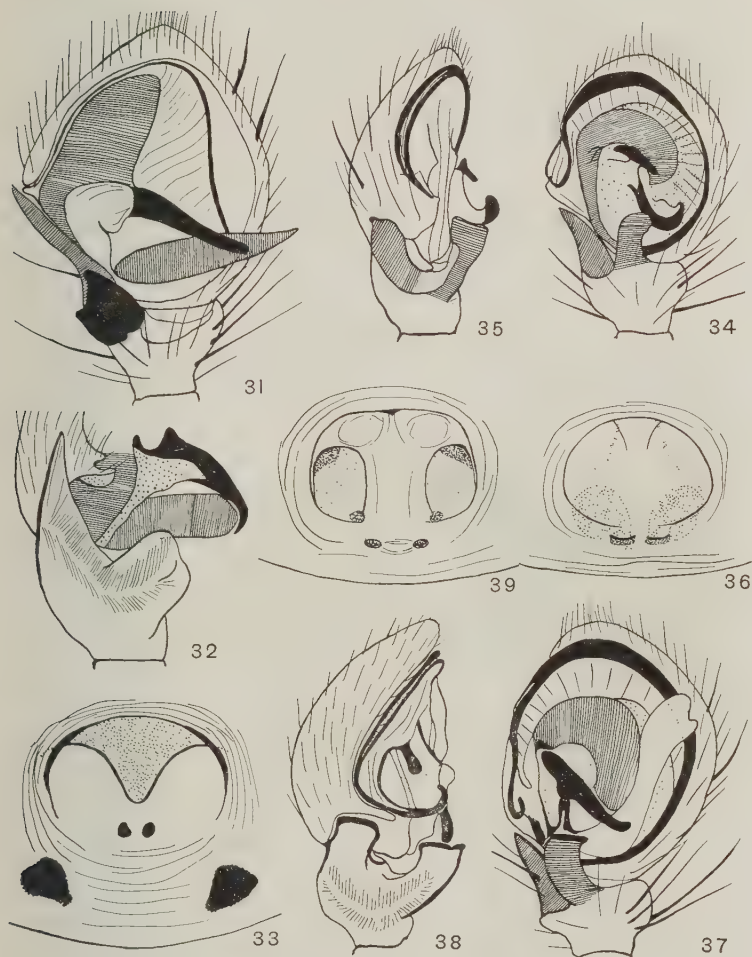
X. limbatus Keyserling, 1880 (male).

X. elegans Comstock, 1913 (female).

X. emertoni Gertsch, 1934.

(Figures 31-33)

This is a very widely distributed species, but it is generally regarded as a northern form. In the collection of the Museum of Comparative Zoölogy there are specimens from several localities in Canada, where it is often abundant, and from New England. There is one female from the mountains of New Mexico. I have both sexes in my Michigan collection from several localities in the vicinity of the University of Michigan Biological Station, Cheboygan County, where I have found the females abundant in July. Females are about 8 mm. long, and males about 6 mm. In females the ground color of the cephalothorax is brownish yellow. Along the lateral margin there is usually a narrow white line and just above it a narrow dark line. A broad light central stripe more or less streaked with brown extends as far back as the beginning of the posterior declivity, but beyond this point it continues a clear yellow without markings. The lateral sides are streaked and mottled with brown. The abdomen has an indistinct central lighter area widening posteriorly with a darker stripe on either side of it; across the posterior half are several lighter recurved bars. The dorsolateral sides are considerably lighter. The venter is yellowish and covered with small



EXTERNAL ANATOMY OF SPIDERS

(Figures 31-39)

- | | |
|--|---|
| 31. <i>Xysticus emertoni</i> , male palpus, ventral view | |
| 32. <i>X. emertoni</i> , tibia and base of tarsus, retrolateral view | |
| 33. <i>X. emertoni</i> , epigynum | 34. <i>Xysticus ferox</i> , male palpus, ventral view |
| 35. <i>X. ferox</i> , retrolateral view | 36. <i>X. ferox</i> , epigynum |
| 37. <i>Xysticus fraternus</i> , male palpus, ventral view | |
| 38. <i>X. fraternus</i> , retrolateral view | 39. <i>X. fraternus</i> , epigynum |

brown dots. The legs have narrow light dorsal stripes with numerous brown dots and larger spots. The male is more distinctively colored. The central cephalothoracic stripe extends from the clypeus to the beginning of the posterior declivity. The remainder of the cephalothorax is reddish brown more or less streaked with yellow. The legs are darker than in the female with a few light spots. Dorsally the abdomen has a series of conspicuous light crossbars and less distinct central and dorsolateral stripes roughly blocking out five pairs of dark spots which diminish in size posteriorly. The epigynum (Fig. 33) is a heavily chitinized structure with its main part distinctly divided into a shallow posterior half and a deeply excavated anterior half. The pits which have been interpreted as the openings to spermathecae are within the main area of the epigynum and are very close together, sometimes being actually united. Two conspicuous black spots lie just posterior to the epigynum. The male palpus (Figs. 31-32) has its tarsal apophyses greatly elongated and pointed prolaterally. The anterior apophysis overlies the other one to some extent. The dorsal lateral tibial apophysis is about half as long as the tarsus; the ventral apophysis is a short stout extension with a distinct retrolateral ridge. Both apophyses are somewhat excavated along the distal margin.

Xysticus ferox (Hentz)

Thomisus ferox Hentz, 1847.

Xysticus stomachosus Keyserling, 1880.

X. stomachosus Emerton, 1892.

X. distinctus Banks, 1892.

X. transversus Banks, 1892.

X. ferox Comstock, 1913.

(Figures 34-36)

Xysticus ferox is another widely distributed species, believed to occur over the greater part of the United States and much of Canada. I have both sexes from several localities in the vicinity of Albion. The female is a little more than 6 mm. long and the male about 5 mm. The female has a cream-colored patch extending from the posterior row of eyes over the clypeus, where it widens considerably. There is the usual light central cephalothoracic stripe, and in this species a small central dark brown spot occurs just where the posterior declivity begins, with a larger spot on each side of it. The remainder of the cephalothorax has the customary brown, mottled coloration.

The abdomen is darker dorsally, with three pairs of indistinct spots bordered with cream color. The lateral sides and venter are lighter. The legs have the color usual for this genus. The colors of the male are like those of the female except that they are more distinct, especially on the abdomen, where the cream-bordered spots show clearly. The epigynum (Fig. 36) is characterized by a simple cavity not usually subdivided by a central septum. In some individuals, however, the presence of a low septum may result in confusing these females with those of *X. elegans*. In the male palpus (Figs. 34-35) the anterior tarsal apophysis is a short, obliquely directed organ attached medially; the posterior apophysis an elongated, low, curved structure. The dorsal lateral tibial apophysis is a simple bladelike process when viewed from below; the ventral apophysis is somewhat expanded distally and turned prolaterally as seen from below.

Xysticus fraternus Banks

X. hamatus Keyserling, 1884 (name preoccupied by Thorell, 1875).

X. hamatinus Banks, 1910.

X. fraternus Bryant, 1930.

(Figures 37-39)

Although apparently much less common in its range than several other species in the genus, *Xysticus fraternus* probably is generally distributed all over the region east of the Rocky Mountains and in the Southwest. A few examples of both sexes have been taken in Michigan in the vicinity of Albion. Females are about 5.5 mm. long and males about 4.25 mm. The female is among the lighter-colored members of this genus. There is a light-colored band between the rows of eyes and the light central cephalothoracic stripe extends from the eyes to the posterior margin. Elsewhere the cephalothorax is pale brown somewhat mottled with yellow. The dorsal area of the abdomen is pale brown with cream-colored broken stripes and bars and with a few brown spots toward the posterior end; the lateral sides are darker. The first two pairs of legs are distinctly darker than the others. The markings in the male are similar but the colors are much more distinct. The cavity of the epigynum (Fig. 39) is clearly divided into two smaller lateral depressions by a low, broad, but very distinct septum. Near the anterior border are two very small, faintly outlined depressions. The oval openings of the sper-

mathecae are separated by a distance equal to a little less than twice the length of one of them. The male palpus (Figs. 37-38) is very different from all others which I have examined. A long flat plate extends somewhat obliquely across the tarsus. The anterior tarsal apophysis is reduced to a small obtuse tubercle, whereas the posterior one is elongated and extended obliquely. Both palpal tibial apophyses are simple processes, the dorsal one having a sharp distal edge and the ventral one being very blunt distally. Both are somewhat excavated retrolaterally.

Xysticus funestus Keyserling

X. brunneus Banks, 1892.

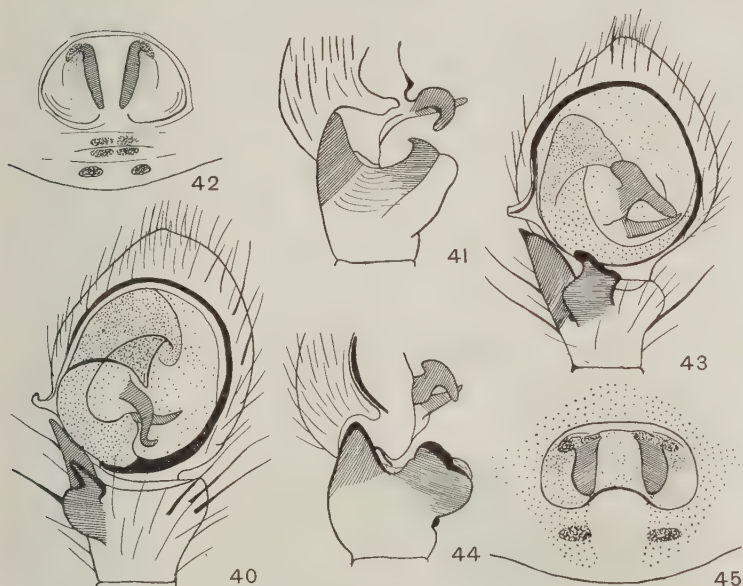
X. crudelis Banks, 1892.

X. nervosus Banks, 1892.

X. nervosus Comstock, 1913.

(Figures 40-42)

In my examination of Banks's types and of several of Emerton's specimens I have been much puzzled in regard to the identification of the females. I am now inclined to believe that Gertsch (1934) has correctly synonymized the group. The folds in the epigynum seem to be variable, and this is the decisive point in making determinations. The species extends from northern New England southward along the Atlantic Ocean to Florida, and westward to Illinois, Missouri, and New Mexico. A few specimens of both sexes have been collected in the vicinity of Albion. Females are about 7 mm. long and males about 3.5 mm. Females have a broken light-colored band between the rows of eyes. The markings of the cephalothorax are much as usual in this genus except that they are lighter and have less differentiation. Dorsally the abdomen is a dirty brown, with small light-colored dots. The legs are somewhat lighter than usual. The male is generally paler than the female; the abdomen is yellow dorsally rather than brown; on the hinder half there are three or four dark bars bordered in front with white. In my specimens the epigynum (Fig. 42) consists of a cavity which is about two thirds as long as wide. Two folds converging posteriorly are the chief features of this organ. Unfortunately, however, these folds seem to vary in the degree to which they are developed and may be almost entirely lacking. Because of this circumstance care must be taken in making determinations. The male palp (Figs. 40-41) is so distinctive that



EXTERNAL ANATOMY OF SPIDERS

(Figures 40-45)

- 40. *Xysticus funestus*, male palpus, ventral view
- 41. *X. funestus*, tibia and base of tarsus, retrolateral view
- 42. *X. funestus*, epigynum
- 43. *Xysticus graminis*, male palpus, ventral view
- 44. *X. graminis*, tibia and base of tarsus, retrolateral view
- 45. *X. graminis*, epigynum

little difficulty will be found in identification. Both tarsal apophyses are elongated, the anterior one overlying and, to some extent, twisting about the posterior one. The dorsal lateral tibial apophysis is a simple, somewhat elongated, bladelike process; the ventral apophysis is bulbous at the base and constricted toward the distal end, which is narrowed and obliquely extended into a beaklike process when seen from below.

Xysticus graminis Emerton

(Figures 43-45)

Xysticus graminis is known from New England to Alabama, and westward to Iowa. My collection from Michigan contains only one

two male palpal tarsal apophyses (Figs. 46-47) are slender clawlike structures somewhat directed toward each other. The lateral tibial apophyses are about equal in length, the tibia being deeply excavated between them; the ventral apophysis is strongly recurved along its distal edge.

Xysticus triguttatus Keyserling

X. feroculus Banks, 1892.

X. triguttatus Emerton, 1892.

X. triguttatus Comstock, 1913.

(Figures 49-51)

Both sexes of this species are represented in my Michigan collection, but all the specimens are from the Northern Peninsula and the region around the University of Michigan Biological Station at Douglas Lake. It is probably not a very common species although it is known to have a wide distribution, from Nova Scotia southward to Virginia and westward as far as Colorado and Texas. Females are about 5 mm. long and males a little less than 4 mm. The sexes differ greatly in general appearance. Females have a brownish yellow cephalothorax, a white eye space, and two whitish lines curving inward from between the posterior median and the posterior lateral eyes and uniting at a dark spot which lies just at the beginning of the posterior declivity. The lateral dark cephalothoracic stripe on each side is partly divided by a lighter stripe. The abdomen is nearly white dorsally and usually has a pair of small black spots near the base and a series of three or four pairs of black spots incompletely united transversely across the posterior half. Comstock's (1913) figures of this species are good for reference. The legs are an amber color. The male is one of the most attractive members of the genus. The first three segments of the first two pairs of legs are a rich mahogany brown; all the remaining segments are yellowish, as are the two posterior pairs of legs. These latter pairs of legs are liberally flecked with brown spots. The cephalothorax is patterned like that of the female but the colors are much deeper. The abdomen is cream color with rich brown spots and bars. The epigynum (Fig. 51) is about two thirds as long as wide. Its cavity contains two thin folds partly enclosing a rather deep channel and lying about as far apart at their posterior ends as the width of one of them. The male palpal tarsus (Figs. 49-50) has a very heavy embolus and a conductor

which almost complete a circle around the periphery of the bulb. The two clawlike tarsal apophyses are directed prolaterally and turned a little toward each other. The dorsal lateral tibial apophysis is recurved at its distal edge; the ventral apophysis is constricted distally and directed obliquely in a beaklike process. Both apophyses are considerably excavated retrolaterally.

PHILODROMINAE

KEY TO THE GENERA OF PHILODROMINAE

1. Second pair of legs much longer than first pair; posterior row of eyes gently recurved; median ocular quadrangle only a little wider behind than in front *Ebo*, p. 217
1. Second pair of legs little if any longer than first pair; posterior row of eyes rather strongly recurved; median ocular quadrangle much wider behind than in front 2
2. Body long and slender, abdomen cylindrical; cephalothorax much longer than wide; posterior lateral eyes somewhat isolated from all others *Tibellus*, p. 232
2. Body shorter and broader, abdomen more or less flattened; cephalothorax nearly as wide as long; posterior lateral eyes not appreciably isolated 3
3. Posterior median eyes closer to posterior laterals than to one another; second pair of legs a little longer than first pair, first pair of legs a little longer than fourth pair *Philodromus*, p. 219
3. Posterior median eyes closer to one another than to the posterior laterals; fourth pair of legs longer than first pair *Thanatus*, p. 231

GENUS EBO KEYSERLING, 1883

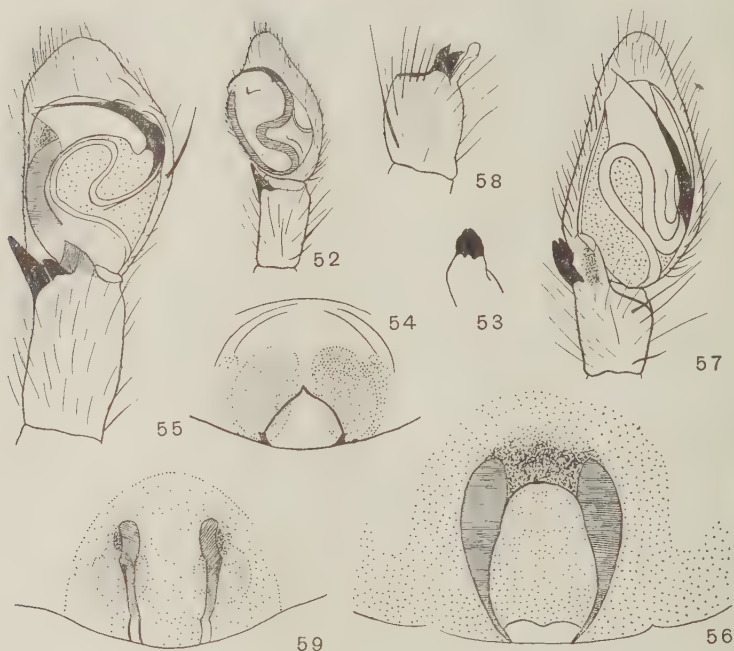
Ebo latithorax Keyserling

E. latithorax Emerton, 1892.

E. latithorax Comstock, 1913.

(Figures 52-54)

This species, one of the smallest of the Thomisidae, is quite well known from New England southward to Virginia and westward to Michigan. I have collected it only three times in Michigan, always from siftings in the vicinity of Albion. I found it once in leaf litter taken from beneath the snow in January, once in April, and once in May; all my specimens were immature. Little is known of the life of this species. Mature females are about 3 mm. long and males about 2.5 mm. The sexes have essentially the same coloration. The cephalothorax is a reddish yellow with dark brown irregular lines



EXTERNAL ANATOMY OF SPIDERS

(Figures 52-59)

- 52. *Ebo latithorax*, male palpus, ventral view
- 53. *E. latithorax*, part of the tibia, retrolateral view
- 54. *E. latithorax*, epigynum
- 55. *Philodromus aureolus*, male palpus, ventral view
- 56. *P. aureolus*, epigynum
- 57. *Philodromus exilis*, male palpus, ventral view
- 58. *P. exilis*, tibia, retrolateral view
- 59. *P. exilis*, epigynum

radiating from the region of the thoracic furrow. The posterior row of eyes is almost straight or very gently recurved. The abdomen is brownish yellow somewhat flecked with irregular brown spots. There are several indistinct chevron-like bars across the posterior half of this part of the body. The epigynum (Fig. 54) is very simple, with a central somewhat depressed area just in front of the genital groove and with two large oval spermathecae lying close together. The male

palp (Figs. 52-53) has a single simple tibial apophysis and a serpentine tube leading to the short evenly curved embolus.

GENUS PHILODROMUS WALCKENAER, 1825

This genus contains the bulk of our Philodrominae; it is a very large genus, rivaling *Xysticus* in the number of its species. Petrunkevitch (1911) listed thirty-eight species for the Western Hemisphere; Comstock (1913) stated that thirty were known for the United States; Berland and Fage (1932) recorded eighteen for France; many new species have been described in recent years. In this genus the posterior row of eyes is moderately recurved; the posterior median eyes are closer to the posterior laterals than to one another; the median ocular quadrangle is much wider behind than in front. The second pair of legs is a little longer than the first pair and the first pair is longer than the fourth. The legs are much longer proportionately in males than in females. The body is flat and broad, the abdomen being somewhat pointed behind. Many of these spiders live on plants, where they are sometimes abundant, but a few spend most of their lives on trees, fences, and buildings. Some are protectively colored and resemble bark, old wood, sand, and the like.

KEY TO THE SPECIES OF *PHILODROMUS*

MALES

1. Embolus describes more than a semicircle around the bulb; tube forms a loop directed transversely prolaterally; palpal tibia about as wide as long (exclusive of the apophyses) 2
1. Combination of features of embolus, tube, and palpal tibia not as above 3
2. Ventral lateral tibial apophysis a long leaflike membranous process; dorsal apophysis a much shorter, stouter process with a distinct distal tooth, directed laterally *P. imbecillus*, p. 223
2. Ventral lateral tibial apophysis a much shorter, slenderer, less membranous process; dorsal apophysis also much slenderer and directed more distally *P. mineri*, p. 226
3. Three distinct tibial apophyses; palpal tibia about twice as long as broad (exclusive of the apophyses); tube of bulb directed retrolaterally *P. aureolus*, p. 221
3. Combination of palpal characters not as above 4
4. Embolus describes a semicircle half way around bulb; tube of bulb makes a loop directed longitudinally 5
4. Embolus describes much less than a semicircle around bulb; tube of bulb makes a loop directed obliquely 6

5. Embolus originates close to ventral lateral tibial apophysis; ventral tibial apophysis a long somewhat bladelike process, dorsal apophysis a small tooth *P. marxi*, p. 225
5. Embolus originates considerably prolateral to ventral tibial apophysis; ventral tibial apophysis a much shorter process, dorsal apophysis longer and somewhat recurved along its distal edge *P. rufus*, p. 228
6. Ventral lateral tibial apophysis a bladelike process which projects retrolaterally at nearly a right angle, dorsal apophysis a simple elongated process distally curved in a ventral direction *P. satullus*, p. 229
6. Ventral lateral tibial apophysis not projecting nearly at a right angle retrolaterally, dorsal apophysis divided distally into two teeth 7
7. Ventral lateral tibial apophysis divided distally into two slender teeth, dorsal apophysis short, stout, deeply excavated retrolaterally
P. infuscatus, p. 224
7. Lateral tibial apophyses not as above 8
8. Embolus originates near middle of bulb, curves acutely near its base; palpal tibia nearly twice as long as broad; ventral lateral tibial apophysis a simple well-chitinized process *P. pernix*, p. 228
8. Embolus originates on prolateral margin of bulb, curves gently near its base; palpal tibia not nearly twice as long as broad; ventral lateral tibial apophysis a thin membranous process *P. exilis*, p. 222

FEMALES

1. Epigynum distinctly longer than wide 2
1. Epigynum usually wider than long or at least as wide as long 4
2. Epigynum with a broad central piece not much narrowed; a single shallow cavity anterior to broad central piece *P. aureolus*, p. 221
2. Epigynum with a central piece distinctly narrowed; a cavity on each side of central piece 3
3. Epigynum with a broad central piece strongly narrowed anteriorly into a distinct septum; a distinct cavity on each side of narrowed septum
P. pernix, p. 228
3. Epigynum with central piece strongly narrowed just in front of genital furrow; two shallow much-elongated lateral cavities nearly coextensive with central piece *P. rufus*, p. 228
4. Epigynum with three more or less distinct lobes 5
4. Epigynum without three more or less distinct lobes 6
5. Epigynum with three clearly defined lobes, central lobe wider at base than at apex; no cavities anterior to base of central lobe
P. infuscatus, p. 224
5. Epigynum with three indistinct lobes, central lobe wider at apex than at base; two shallow oval cavities at base of central lobe *P. satullus*, p. 229
6. Epigynum with a distinct central piece; two shallow cavities either lateral to the central piece or anterior to it and separated from one another by not more than the diameter of one of them 7
6. Epigynum without a distinct central piece; shallow cavities always in anterior part of epigynum and farther apart than the diameter of one of them 8

7. Epigynum with a central piece more than twice as long as broad; large indistinct oval somewhat depressed areas lateral to central piece
P. mineri, p. 226
7. Epigynum with a central piece less than twice as long as broad; more distinct small oval cavities anterior to base of central piece and about as far apart as the diameter of one of them *P. marxi*, p. 225
8. Cavities of the epigynum farther apart; spermathecae circular, farther from the genital furrow; somewhat smaller species *P. exilis*, p. 222
8. Cavities of the epigynum closer together; spermathecae larger, somewhat oval, closer to the genital furrow; somewhat larger species
P. imbecillus, p. 223

Philodromus aureolus (Clerck)

Araneus aureolus Clerck, 1757.

P. aureolus Keyserling, 1880.

P. canadensis Emerton, 1917.

(Figures 55-56)

This appears to be the most common *Philodromus* in Michigan, and I have many specimens of both sexes from both the Northern and Southern peninsulas. The species is common throughout most of Canada, the United States, and Europe, where several varieties are recognized. Females are a little less than 5 mm. long and males about 4 mm. Females have a light-colored central cephalothoracic stripe, about as wide as the eye group, extending from the anterior eyes to the posterior border of this part of the body. The lateral sides of the cephalothorax are reddish brown, with a little yellow along the margin. The abdomen is slightly lobed at its base. Its ground color is a very light yellow; there is a reddish brown lanceolate stripe at the base, and much of the remaining area is reddish brown. The lateral sides have some darker brown. The underparts are all light-colored. The legs have some of the reddish brown color, which is intensified at the distal ends of many of the segments. The color pattern of the male is like that of the female but is much more clearly outlined. The epigynum (Fig. 56) is very distinctive, consisting of a broad central piece flanked on either side by a narrow dark-colored somewhat curved piece. There is a central shallow cavity just anterior to the central piece. The male palpus (Fig. 55) has its patella longer than its tibia (exclusive of the apophyses). There are three tibial apophyses, the ventral one being a stout bladelike process, the intermediate one a small tooth, and the dorsal one a long strong process somewhat flattened apically.

Philodromus exilis Banks*P. bidentatus* Emerton, 1892.

(Figures 57-59)

In my collection of Michigan spiders I have both sexes of *Philodromus exilis* from a few localities in the Southern Peninsula but neither from the Northern Peninsula. It is probably not a very common species, although it is known from Nova Scotia along the Atlantic region as far south as Virginia and westward to New Mexico. Both sexes are about 3.5 mm. long. In females the light-colored median cephalothoracic stripe is bright yellow. It includes the eye space and the whole clypeus. The lateral sides of the cephalothorax are a dark walnut brown speckled a little with dull yellow and there is a little yellowish color along the lateral margin. The abdomen is slightly lobed at its base. There is a fairly clear basal central lanceolate stripe. The lateral sides of the abdomen are brown; about midway this color extends dorsally and shows faintly across the dorsal surface, often making a very distinctive mark. Incomplete light and dark chevrons occur on the posterior half. The underparts are all yellowish. The legs are yellowish somewhat dotted with brown. The males in my collection are all much less brightly colored than the females. The central light cephalothoracic stripe has a good deal of brown in it and does not include the clypeus. Dorsally the abdomen shows very little of the bright colors of the female; the fundamental pattern is present but is obscured by the greater amount of colored surface. The epigynum (Fig. 59) is very simple, consisting essentially of a low mound with two small crescentic cavities more than twice the length of one of them apart and about as far from the genital furrow as they are separated from one another. Faint lines or ridges connect the cavities with the posterior margin and these lines converge slightly just in front of the genital furrow. The male palpus (Figs. 57-58) is quite distinctive. The patella is longer than the tibia (exclusive of the apophyses) in the ratio 4:3. The tibia is a little longer than it is broad. The ventral lateral tibial apophysis is a blunt somewhat membranous process; the dorsal apophysis is a stout well-chitinated structure bidentate apically. The embolus arises on the prolateral side and gently curves near its base; the loop of the tube originates near the base of the bulb and is directed somewhat obliquely.

Philodromus imbecillus Keyserling*P. lineatus* Emerton, 1892.*P. carolinus* Banks, 1911.

(Figures 60-61)

This species is probably best known from New England but it has a wide distribution as far southward as Florida and westward to the Mississippi River. I have found it abundant in marshy places in the vicinity of Albion and in other localities in the southern part of the state, but I have never found it elsewhere. Females are about 4.25 mm. long and males about 3.3 mm. Emerton's name for this species was well chosen, because its conspicuous oblique abdominal lines give it considerable distinction. Ordinarily in females the median light-colored cephalothoracic stripe begins with the clypeus and continues broadly to the posterior margin. The lateral sides of the cephalothorax are reddish brown with a slightly yellowish margin. The abdomen is white dorsally with a reddish brown basal lanceolate stripe and a series of five or six pairs of oblique reddish brown bars across the posterior two thirds. The lateral sides are usually supplied with much of the reddish brown color. Quite frequently, however, the brown may be nearly lacking and the dorsal area almost pure white. The legs are light reddish brown with a strong tendency toward light and dark stripes. Males are much darker in color and many show very little of the striking pattern of the female. The epigynum (Fig. 61) is very similar to that of *Philodromus exilis*. There are two small cavities less than the length of one of them apart and farther from the genital groove than they are from one another. The posterior boundaries to the central part diverge slightly just before meeting the genital furrow. The spermathecae are large, oval, and separated from one another by the width of the central part of the epigynum. The patella of the male palpus (Fig. 60) is longer than the tibia in the ratio of 14:9. The embolus originates on the retrolateral side of the bulb; the loop arises from the retrolateral side and is directed transversely. The ventral lateral tibial apophysis is nearly as long as the tibia, somewhat flattened, and membranous; the dorsal apophysis is short, broad at its base, and toothed distally.

Philodromus infuscatus Keyserling*P. unicolor* Banks, 1892.*P. macrolarsus* Emerton, 1917.

(Figures 62-64)

Of this species from Michigan I have but two specimens, both females. One is from Old Mission, the other from Albion. The species is known from Ontario, Canada, New York, Virginia, Maryland, and Michigan. It is probably not a very common species



EXTERNAL ANATOMY OF SPIDERS

(Figures 60-67)

- 60. *Philodromus imbecillus*, male palpus, ventral view
- 61. *P. imbecillus*, epigynum
- 62. *Philodromus infuscatus*, male palpus, ventral view
- 63. *P. infuscatus*, male palpus, retrolateral view
- 64. *P. infuscatus*, epigynum
- 65. *Philodromus marxi*, male palpus, ventral view
- 66. *P. marxi*, tibia, retrolateral view
- 67. *P. marxi*, epigynum

anywhere, but it is likely to be widely distributed. In females the abdomen is quite noticeably bilobed at the base. The general coloration is gray. The cephalothorax lacks the median light stripe, and just behind the eyes there is a poorly defined dark spot. The clypeus is unusually swollen in this species. The abdomen is gray with faint darker oblique bars across the posterior half and along the lateral sides. The legs are yellowish, with small irregularly arranged dark spots. The underparts are all very light-colored. The general coloration of the male is similar to that of the female, but the colors are duller and less distinctive. The epigynum (Fig. 64) is quite unlike that of any other I have seen among the philodromids. There are three well-defined lobes; the openings are apparently at the anterior ends of the slits separating the median lobe from the two lateral lobes. In the male palpus (Figs. 62-63) the tibia is a little wider than long because the dorsal apophysis is extended so far laterally. The patella is about as long as the tibia. The ventral lateral tibial apophysis is turned toward the tarsus and bifurcated distally into parallel pointed processes; the dorsal apophysis is a stout, laterally extended, and deeply excavated process. The embolus originates near the anterior end of the bulb and curves gently to its termination; the loop arises on the prolateral side of the bulb near the base and is directed somewhat obliquely across it.

Philodromus marxi Keyserling

P. ornatus Banks, 1892.

P. minusculus Banks, 1892.

(Figures 65-67)

Although this species is now known from several localities all the way from New England southward to North Carolina and westward as far as Texas and, possibly, even as far as California, I have only one mature individual, a female, from southern Michigan. It is regarded as a rather uncommon species. Females are among our most clearly marked philodromids. The clypeus is a light dusty brown. The usual central cephalothoracic light-colored stripe begins with the eye space and continues to the posterior border. The lateral sides of the cephalothorax are a rich walnut brown. The abdomen is nearly all white dorsally; the lateral sides are dark brown, and about midway these colored regions extend dorsally, as noted in Banks's original description. The legs and the underparts are

a light yellowish color. It has been impossible to examine freshly preserved males, but those long in alcohol show little of the light coloration so characteristic of females. The light cephalothoracic stripe is indistinct, and apparently the abdomen is quite completely covered with a light brown color. The epigynum (Fig. 67) has a central piece resembling that of *Philodromus mineri*, though it is less elaborate. The cavities are small and lie anterior to the central piece. In the male palpus (Figs. 65-66) the patella is about as long as the tibia. The embolus originates at the proximal end of the tarsus, turns acutely near its base, and curves gently to its termination. The loop also originates near the base of the tarsus and is directed longitudinally instead of nearly transversely as in *P. mineri*. The ventral lateral tibial apophysis is a long, rather broad, somewhat membranous process. The dorsal apophysis is a sharp tooth of moderate size.

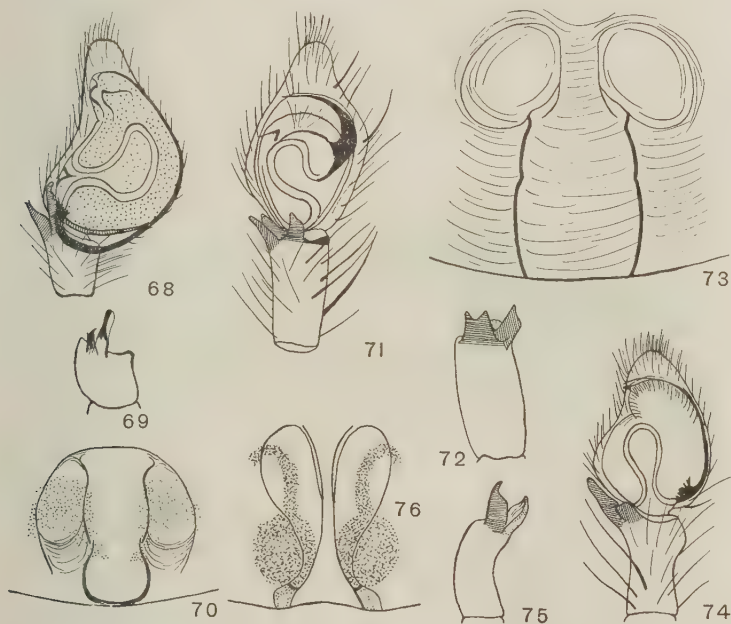
Philodromus mineri Gertsch

P. emertoni Bryant, 1933.

(Figures 68-70)

Dr. Gertsch's type came from Douglas Lake, Michigan. Miss Bryant's type came from a collection which belonged originally to Mr. J. H. Emerton and which he obtained from North Carolina. Though little is known about the species it is believed to be widely distributed over the country east of the Rocky Mountains. It is not likely to be a very common species except, perhaps, locally. I have collected mature individuals only once in Michigan, in the vicinity of Albion. Females are about 4.5 mm. long and males about 3.5 mm. In females the light-colored median cephalothoracic stripe is very broad and includes the eyes and the whole clypeus. The lateral sides are a reddish brown with a little yellow along the margin. The abdomen is somewhat bilobed at its base. Dorsally it is all light-colored, with a few brown flecks and indistinct light oblique bars across the posterior half. The legs are all light yellowish with a few brown flecks here and there. The underparts are all light yellowish dotted a little with brown. The epigynum (Fig. 70) has a well defined central piece with a large oval area (which I consider to be a shallow depression) on each side. The embolus of the male palpus (Figs. 68-69) originates close to the ventral lateral tibial apophysis and curves rather acutely at first, and then more gently,

to its termination; the loop arises on the retrolateral side and lies nearly transversely across the bulb. The ventral lateral tibial apophysis is a membranous process, somewhat elongated and extending in close contact with the tarsus considerably beyond the origin of the embolus; the dorsal apophysis is a well-chitinized, elongated process, bifurcated distally into a short denticle and a longer hooklike extension. The patella is slightly longer than the tibia (exclusive of the apophyses).



EXTERNAL ANATOMY OF SPIDERS

(Figures 68-76)

- 68. *Philodromus mineri*, male palpus, ventral view
- 69. *P. mineri*, tibia, retrolateral view
- 70. *P. mineri*, epigynum
- 71. *Philodromus pernix*, male palpus, ventral view
- 72. *P. pernix*, tibia, retrolateral view
- 73. *P. pernix*, epigynum
- 74. *Philodromus rufus*, male palpus, ventral view
- 75. *P. rufus*, tibia, retrolateral view
- 76. *P. rufus*, epigynum

Philodromus pernix Blackwall*P. vulgaris* Emerton, 1892.*P. pernix* Comstock, 1913.

(Figures 71-73)

This is another species which is believed to be distributed over most of the United States and much of Canada. It is one of our most common philodromids in southern Michigan, but I have not collected it in the Northern Peninsula. Females are about 5.25 mm. long and males about 4 mm. Emerton's (1902) figures are good for the form and color pattern of this species. In females the usual median light stripe and the dark lateral sides are present on the cephalothorax. Two white bands unite behind the eyes to make a procurved figure. The abdomen has a more or less distinct basal central lanceolate stripe and the posterior two thirds of the dorsum bears a herringbone pattern of alternate light and dark bars. The lateral sides are dark brown and the underparts are all light-colored. The legs are yellowish spotted with brown. In life these spiders are often coated with a fairly thick covering of hair which obscures the color pattern. The coloration of the male is much the same as that of the female except that it is dull and indistinct. The epigynum (Fig. 73) has a prominent central piece which is strongly narrowed anteriorly; on each side of the narrowed part is a prominent cavity. Frequently these cavities are filled with a hard transparent substance and are, therefore, more or less obscured. The tibia of the male palpus (Figs. 71-72) is distinctly longer than its patella. The embolus arises near the anterolateral side, curves acutely near its base and then evenly to its termination. The loop originates on the prolateral side and is directed in an oblique direction across the bulb. The ventral lateral tibial apophysis is a simple stout tooth; the dorsal apophysis is a flat bladelike process bifurcated distally into sharp teeth.

Philodromus rufus Walckenaer*P. pictus* Emerton, 1892.

(Figures 74-76)

Philodromus rufus Walckenaer has a very wide distribution over the whole of the United States, much of Canada, and most of Europe. I have mature females from both Michigan peninsulas but no mature

males; yet I consider the species fairly common in the state. Females are about 4.5 mm. long and males a little smaller. The median cephalothoracic stripe is very light yellow, the lateral sides of the cephalothorax reddish brown. The abdomen is yellowish along the median dorsal region but laterally it is reddish brown. Faint oblique bars show across the posterior half of this part of the body. The underparts are all light yellowish and the legs are yellowish with small brown dots irregularly distributed over them. The male is colored like the female except that it is much darker and has less pattern. The epigynum (Fig. 76) has a long central piece which is strongly narrowed just a little in front of the genital groove. On each side of the central piece is a long slender shallow cavity. The male palpal tibia is strongly curved dorsally (Fig. 75) and is a little longer than the patella. The embolus (Fig. 74) arises considerably prolateral to the ventral lateral tibial apophysis; the loop originates at the base of the bulb and is directed longitudinally. The ventral lateral tibial apophysis is shorter (foreshortened in the figure because of position in which it was viewed) than the dorsal apophysis, and quite membranous; the dorsal apophysis is longer, well chitinated, and apically produced into a distinct hook.

Philodromus satullus Keyserling

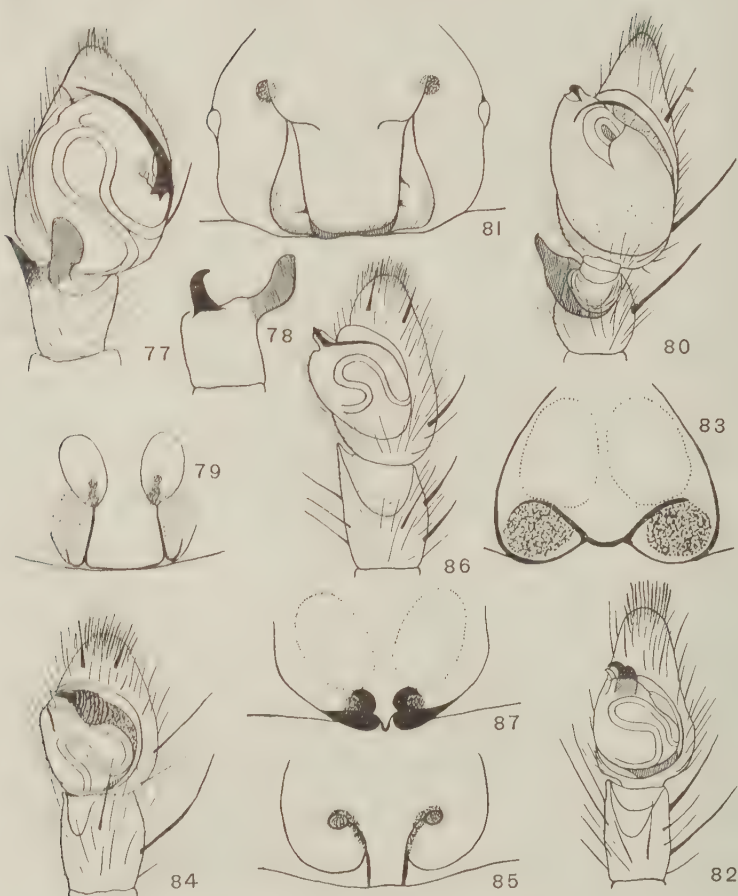
P. minutus Banks, 1892.

P. brevis Emerton, 1892.

P. minutus Comstock, 1913.

(Figures 77-79)

This species is represented in my Michigan collection by immature females and one mature male, all collected in the vicinity of Albion. It is probably not a very common species anywhere, but it is now known from numerous localities in New England, New York, the middle western states, and the far west as far as Washington and California. Females are about 4 mm. long and males about 3.25 mm. The cephalothorax of the females has the usual light median stripe and dark lateral sides. A procurved patch of white occurs just behind the eyes. A dark median basal dorsal abdominal stripe is fairly distinct, and a less distinct dark bar may be observed across the middle of the abdomen. The dorsolateral sides are dark reddish brown, and there are light bars across the posterior third of the abdomen. The legs are generally dark brown with some indi-



EXTERNAL ANATOMY OF SPIDERS

(Figures 77-87)

- | | |
|---|-----------------------------------|
| 77. <i>Philodromus satullus</i> , male palpus, ventral view | 79. <i>P. satullus</i> , epigynum |
| 78. <i>P. satullus</i> , tibia, retrolateral view | |
| 80. <i>Thanatus formicinus</i> , male palpus, ventral view | |
| 81. <i>T. formicinus</i> , epigynum | |
| 82. <i>Tibellus duttoni</i> , male palpus, ventral view | 83. <i>T. duttoni</i> , epigynum |
| 84. <i>Tibellus maritimus</i> , male palpus, ventral view | |
| 85. <i>T. maritimus</i> , epigynum | |
| 86. <i>Tibellus oblongus</i> , male palpus, ventral view | 87. <i>T. oblongus</i> , epigynum |

cations of stripes. The colors of the male are less distinct but are otherwise like those of the female. The epigynum (Fig. 79) is indistinctly divided into three lobes near the genital furrow, the central piece being about as long as wide and having two shallow oval cavities just anterior to it and separated from one another by less than the diameter of one of them. In the male palpus (Figs. 77-78) the embolus originates on the prolateral side of the bulb and is gently curved at its base; the loop arises at the prolateral basal corner and is directed obliquely across the bulb; the ventral lateral tibial apophysis is a bladelike membranous process which projects almost at a right angle; the dorsal apophysis is a well-chitinized process curved ventrally into a distinct hook.

GENUS THANATUS C. KOCH, 1837

Thanatus formicinus (Clerck)

T. lycosoides Emerton, 1892.

T. lycosoides Comstock, 1913.

T. formicinus Simon, 1932.

T. canadensis Gertsch, 1933.

(Figures 80-81)

There appears to be only one species of *Thanatus* in Michigan, although Kaston (1938) recently recognized two in Connecticut. Mature individuals of both sexes are in my collection from the two Michigan peninsulas, and I regard *T. formicinus* as fairly common in the state. In the past there has been much confusion regarding *Thanatus* in the United States. Emerton himself synonymized *T. lycosoides* with *T. coloradensis* Keyserling. Petrunkevitch (1911) did the same thing, and for thirty years the two were regarded as the same species. Recently, through the publications of Gertsch (1933, 1934) and through further work by Miss Bryant on the collections in the Museum of Comparative Zoölogy, the status of the species which we have in this country has been clarified. It is now known to be widely distributed over the northeastern part of the United States, eastern Canada, and most of Europe. Mature females are about 8 mm. long and males only a little smaller though their legs are longer. The cephalothorax is very slightly longer than broad, and the whole body is well supplied with a coating of hair. The posterior row of eyes is strongly recurved; the posterior median

eyes are a little closer to one another than to the posterior laterals; the anterior laterals are closer to the anterior medians than they are to the posterior medians; and the ocular quadrangle is much wider behind than in front. The coloration is essentially the same in the two sexes and recalls the general coloration of many of the Lycosidae. The cephalothorax has a median light stripe from the anterior eyes to the posterior margin, but this light stripe includes within it a shorter and smaller stripe from the posterior eyes back to the region of the thoracic furrow. Comstock's figures (1913) will help beginners to fix the essential facts concerning the form and color pattern of this species in their minds. The lateral sides of the cephalothorax are a dark brown more or less broken by a lighter stripe which lies near the lateral margin. The brownish abdomen has a conspicuous black basal dorsal lanceolate stripe extending a little more than half its length. The legs are generally dark brown, but there are prolateral and retrolateral femoral stripes. The epigynum (Fig. 81) is somewhat broader than long, and there is a broad central scutiform depression within which lies a broad flat, distally spatulate septum. The male palpus (Fig. 80) has a swollen bulb obliquely placed in the tarsus and a simple massive tibial apophysis.

GENUS *TIBELLUS* SIMON, 1875

In this genus the whole body is long and slender; the cephalothorax is much longer than broad and the abdomen is very long and cylindrical. These spiders are usually light yellowish (sometimes reddish), with dark brown stripes and spots. They are the largest of our philodromids and are usually found on low bushes, weeds, and grasses. The posterior row of eyes is so strongly re-curved that the eyes nearly form a semicircle; the anterior eyes and the posterior medians are grouped together in such close proximity that the posterior laterals are left somewhat isolated. The median ocular quadrangle is much wider behind than in front; the posterior median eyes are much nearer one another than they are to the posterior laterals. The American species of *Tibellus* have been in much confusion until recently, when Miss Bryant (1933) and Gertsch (1933) together greatly clarified their status. Three species have been reported from Michigan; I am including all of them in this paper, even though I have not collected *T. duttoni* in the state.

Gertsch (1933) has given careful technical descriptions of the three species which occur in our region.

KEY TO THE SPECIES OF *TIBELLUS*

MALES

1. Anterior tibiae with four pairs of ventral spines; embolus with a distinct distal hook (Fig. 82) *T. duttoni*, p. 233
1. Anterior tibiae with three pairs of ventral spines; embolus without a distinct distal hook 2
2. Embolus much swollen and coarsely grooved just behind the tip
T. maritimus, p. 234
2. Embolus not swollen just behind the tip, and finely grooved near the apex
T. oblongus, p. 234

FEMALES

1. Anterior tibiae with four pairs of ventral spines; lateral boundaries of epigynum much more than half as long as broad, constricted anteriorly
T. duttoni, p. 233
1. Anterior tibiae with three pairs of ventral spines; lateral boundaries of epigynum only about half as long as broad, not constricted anteriorly 2
2. Width of central piece of epigynum at its posterior end much greater than diameter of openings; openings separated from posterior margin by several diameters *T. maritimus*, p. 234
2. Width of the central piece of epigynum about equal to diameter of openings; openings separated from posterior margin by scarcely one diameter
T. oblongus, p. 234

Tibellus duttoni (Hentz)

Thomisus duttoni Hentz, 1847.

Tibellus duttoni Keyserling, 1880.

T. duttoni Gertsch, 1933.

T. duttoni Kaston, 1938.

(Figures 82-83)

According to Gertsch (1933), this is the spider which Hentz described from Georgia, where it is the most common species. It is found in the southeastern part of the United States from Florida to Texas, and into Mexico, and extends northward into Minnesota and Michigan and eastward to southern New England. Females are about 9.5 mm. long and males about 7 mm. Two pairs of dark dorsal spots are usually found at the posterior end of the abdomen. The anterior tibiae have four pairs of ventral spines, whereas each of the other two species in our fauna has but three pairs. The epigynum (Fig. 83) has lateral margins considerably longer than

those of *Tibellus maritimus* and constricted anteriorly; the central piece is very short, and the apertures are close to the posterior margin of the epigynum and relatively far apart. The embolus of the male palpus (Fig. 82) is distinctly hooked at its apex.

Tibellus maritimus (Menge)

Thanatus maritimus Menge, 1874.

T. oblongus Menge, 1874.

Tibellus oblongus Simon, 1875.

T. maritimus Kulczynski, 1908.

T. maritimus Gertsch, 1933.

T. maritimus Kaston, 1938.

(Figures 84–85)

This species seems to have about the same extensive range as *Tibellus oblongus*, but it is everywhere less common. I have the two sexes in my collection from both peninsulas of Michigan. Females are about 7.3 mm. long and males about 6.2 mm. Gertsch (1933) states that it is very difficult, perhaps impossible, to separate this species from *T. oblongus* on the basis of color, body form, leg spines, proportions of the various organs, or the like. The distal black spots on the dorsum of the abdomen are usually lacking. The epigynum (Fig. 85) is readily distinguishable from that of any other species in our region. The openings are farther from the genital furrow and the septum is more distinct than in the other species. The lateral boundaries do not extend as far anteriorly nor are they noticeably constricted at the anterior ends. The embolus of the male palpus (Fig. 84) is much swollen just behind the apex, and deeply grooved.

Tibellus oblongus (Walckenaer)

Aranea oblonga Walckenaer, 1802.

Thanatus oblongus Menge, 1874.

Tibellus oblongus Keyserling, 1880.

T. duttoni Emerton, 1892.

T. oblongus Gertsch, 1933.

T. oblongus Kaston, 1938.

(Figures 86–87)

This is by far the most common *Tibellus* in Michigan; I have it in my collection from many localities in both peninsulas. It is widely distributed over Europe, Asia, all of southern Canada, the whole of the United States, and; probably, much of northern Mexico. Females are a little less than 8 mm. long and males a little less than

7 mm. In males there are three dark cephalothoracic stripes, one median and two lateral. The intervals between the lateral stripes and the median stripe are light yellow, sometimes dotted with brown or black. The eye tubercles are black. Quite frequently the whole body and the legs acquire a reddish color. The dorsum of the abdomen ordinarily has a median and two lateral brown stripes. At each side of the median stripe near the posterior end of the body is a small black spot. The second pair of legs is the longest. The anterior tibiae have three pairs of ventral spines. Females are colored like the males except that they are usually much lighter. The epigynum (Fig. 87) has a very short and narrow septum; the apertures are close together and also close to the posterior margin. The embolus of the male palpus (Fig. 86) is finely grooved at the tip and not bulbous as in *T. maritimus* or hooked as in *T. duttoni*. There is also a short tibial apophysis.

ALBION COLLEGE
ALBION, MICHIGAN

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LAMPREYS OF THE GENUS *ENTOSPHENUS* FROM WISCONSIN AND NORTHERN MICHIGAN *

CHARLES W. CREASER

NONPARASITIC brook lampreys of the genus *Entosphenus* are currently designated as *Entosphenus lamottenii* (Le Sueur) by Hubbs and Trautman (1937, p. 24). Owing to the seasonal occurrence of the adults of such lampreys records of them are rather rare; hence two collections of some interest are reported here.

The most recent statement of the range of *Entosphenus lamottenii* is given by Greene (1935, p. 23), as follows:

Range: Minnesota and Iowa, eastward to Connecticut and Maryland, and from northern Michigan, southern Ontario and New York southward to the Illinois and Ohio rivers.

Wisconsin collections examined: (1) Big Cr., trib. Black R., Monroe Co.; (2) Duck Cr., S.E. Wisconsin Rapids, Wood Co.; (3) Coon R., 1 mile S. Stoddard, Vernon Co.; (4) Otter Cr., trib. Lake Koshkonong, Jefferson Co.; (5) White Cr., near Easton, Adams Co.; (6) Cr. at Fall River, Columbia Co.

The northernmost points from which this species was collected in Wisconsin are Big Cr., Monroe County, and Duck Cr., Wood County. The fact that no records are available for the Great Lakes basin in Wisconsin indicates a Mississippi center of distribution post-glacially, with a southern route of dispersal to Michigan and the east (Chicago and Maumee outlets). The present paucity of records, however, does not justify a conclusion that it failed to use the St. Croix or Fox connectives. It is probable that collecting in the early spring will prove *Entosphenus* to be quite common in the Lake Michigan and Lake Superior drainages.

Recently we received a collection of brook lampreys from a creek crossing the country club golf course at Kenosha, Wisconsin, made by Miss M. E. Creaser on April 29, 1934. All these are *Entosphenus lamottenii*, and the locality is in the Lake Michigan drainage system.

* Contribution from Wayne University and the University of Michigan Biological Station. This study was aided by the National Youth Administration and the Zoology Research Fund of Wayne University.

It is also of interest to note that this species occurs in the Lake Superior drainage basin, from which it has not hitherto been reported. A specimen was collected by a group of my students on July 4, 1938, from Miner's River, a stream flowing into Lake Superior from Miner's Lake, east of Munising, Michigan (Munising Township, Sec. 10, T. 47 N., R. 18 W.). It was one of a group which, to judge from their action, were spawning in this stream a few feet from Lake Superior. It is to be noted that in this species spawning occurs the first of April in the Kenosha and Detroit areas; in early May in the region of Douglas Lake, Cheboygan County, Michigan; and in late June or early July along the southern shore of Lake Superior.

We do not yet have from Lake Superior a specimen of the marine lamprey, *Petromyzon marinus*, which has been spreading in the upper lakes during the past few years and which is now fairly abundant in the northern part of Lake Huron (Hubbs and Pope, 1937).

Louis Agassiz (1850) recorded under the name *Ammocoetes borealis* a lamprey ammocoete found at Michipicoten, Ontario, Canada, on the northeastern shore of Lake Superior. From the description of the dorsal fin of this larval form it certainly is an *Ichthyomyzon*. Since material from the region of Michipicoten is lacking and since both species may be found, it is not possible at this time to tell which of the two species Agassiz collected.

We may, therefore, list as follows the lampreys now known to occur in the Lake Superior watershed:

FAMILY PETROMYZONIDAE LAMPREYS

I. Genus *Ichthyomyzon*

1. *Ichthyomyzon unicuspis*, Hubbs and Trautman, northern lamprey
Mouth of Amicon River, Douglas Co., Wisconsin; Hubbs and Schultz, June 3, 1926; cited by Hubbs and Trautman (1937), p. 59; map on p. 44.
2. *Ichthyomyzon fessor*, Reighard and Cummins, northern brook lamprey
Au Train River, Alger Co.; V. D. La Baw, June, 1934; cited by Hubbs and Trautman (1937), p. 68; map on p. 44.

II. Genus *Entosphenus*

3. *Entosphenus lamottenii* (Le Sueur), American brook lamprey

Mouth of Miner's River as it flows into Lake Superior from Miner's Lake near Pictured Rocks, State Park, July 4, 1938.

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MORPHOLOGY OF THE IMMATURE STAGES OF SOME NORTHERN MICHIGAN DONACIINI (CHRYSEMELIDAE; COLEOPTERA) *

CARL E. HOFFMAN

THE Donaciini are a group which has developed unusual adaptations to life in water, particularly in the immature stages. Before any attempt can be made to discuss these adaptations it is necessary to know the structural features which separate the early stages of the different species. This paper, describing the morphology of such stages of eleven species of Donaciini from the Douglas Lake region, Cheboygan County, Michigan, is the first of a series on the general biology of the Donaciini. The remaining parts of the study will deal with the limnological relations of the Donaciini and the respiration of the larvae.

Very little is known about the immature stages of the Donaciini that occur in this country. Only two authors (Sanderson, 1900; MacGillivray, 1903) have made significant contributions to the life histories of American Donaciini. Their investigations, although furnishing much valuable information, are incomplete. Of the eleven species occurring in the Douglas Lake region, five have been considered by these authors. Sanderson described the larvae of *Haemonia nigricornis* Kirby and the eggs and larvae of *Donacia piscatrix* Lacordaire. MacGillivray studied the eggs and larvae of *Donacia cincticornis* Newman and the larvae of *Haemonia nigricornis* Kirby, *Donacia aequalis* Say, and *Donacia subtilis* Kunze. Because their descriptions of the eggs of the species they studied do not conform to those of the author and because their accounts of the larvae are incomplete it is necessary to consider these five species along with the six new ones. The general characteristics of Donaciini larvae have been studied by various persons; Böving (1910) describes and pictures the morphology of larvae of Danish Donaciini.

* Contribution from the Biological Station and the Department of Zoölogy, University of Michigan.

SPECIES CONSIDERED

All stages of the species studied were collected by the writer in the vicinity of Douglas Lake. The following species are discussed in this paper:

Haemonia nigricornis Kirby	Donacia quadricollis Say
Donacia piscatrix Lacordaire	Donacia subtilis Kunze
Donacia proxima Kirby	Donacia aequalis Say
Donacia cincticornis Newman	Donacia pubicollis Suffrian
Donacia hirticollis Kirby	Donacia flavipes Kirby
Donacia pubescens Le Conte	

All but one of these species were identified by Mr. H. S. Barber, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D.C. *Donacia pubicollis* Suffrian was identified by the writer and checked against specimens in the University Museums, University of Michigan, which had been determined by Mr. C. Schaeffer.

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The author wishes to express his indebtedness to Professor Paul S. Welch, under whose direction this work was done; to Mr. H. S. Barber, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, for the identifications of the Donaciini studied; to Professor J. H. Ehlers for the determination of aquatic plants; and to various other persons for valuable assistance.

MORPHOLOGY

GENERAL DISCUSSION

No attempt is made here to discuss any morphological characteristics of the Donaciini other than those which are of systematic value in separating the eleven species studied. For a detailed account of the complete morphological characteristics the reader is referred to Böving (1910). Before describing the different species the taxonomic characteristics used in this paper will be reviewed. All the following general material and specific descriptions were taken from last larval instars. The first study was made from the exuviae found in the cocoon with the fully formed imago. The characteristics noted were then checked against those larvae which had not formed cocoons.

LARVAE (Pl. II, Figs. 13-23)

The length of the larvae at the time of formation of the cocoon ranges from 8-10 mm. in *Donacia aequalis* to 13-16 mm. in *D. pubicollis*. *Donacia* larvae are either white or cream-colored; those of *Haemonia nigricornis* are green. The larvae have ten abdominal segments, of which the eighth, ninth, and tenth are greatly reduced, except in *D. piscatrix*, *D. cincticornis*, and *D. proxima*. In the eighth abdominal segment the dorsum is equipped with a pair of caudal spines, which the larva may use to penetrate aquatic plants. The size of the caudal spines varies in relation to the rest of the body in the different species, being greatest in *D. proxima*, *D. cincticornis*, and *D. piscatrix*, and comparatively short in all the others. The legs are small and short as compared with the rest of the body in all species except *H. nigricornis*, in which they are usually very prominent. Each leg is composed of three joints and a terminal sclerotized claw, which in all the American forms studied is equipped with a distinct heel and a sickle-shaped part. The curvature of this part and the prominence of the heel vary in general with the species studied, but not sufficiently to be used as specific characters. Nor have specific characters such as MacGillivray (1903) recorded been found in the number of setae on the legs. The head is small and directed forward, either extending free or being completely withdrawn into the prothorax. The general shape of the larvae differs in various species. Some taper gradually anteriorly and posteriorly from the middle of the body; others are not greatly reduced in the sixth and seventh abdominal segments. In *Donacia* the dorsum of the seventh segment is always rounded transversely and is in a dorsal or posterior position. In *H. nigricornis* half of the dorsum of this segment is in a posterior position and the other half is flattened and ventral, as though it were a continuation of the ventral surface (Pl. II, Fig. 13). The posterior part of this dorsum in *H. nigricornis* is bluntly pointed.

OCELLI

The ocelli are small spots of black pigment on each side of the parietalia. The usual number is five, arranged in two rows, three in front and two in back. Just before ecdysis the eyes are not visible, which probably explains why MacGillivray (1903) recorded them as wanting in some of the species he described. *Donacia pubescens* has

four ocelli in two rows, two in front and two at the back. *D. pubicollis*, *D. piscatrix*, and *D. flavipes* usually have five, but the number and arrangement vary. Within other species the ocelli sometimes vary in number, but in so very few specimens that the eyes can be used as a character when comparing *D. pubescens* with species other than *D. pubicollis*, *D. piscatrix*, and *D. flavipes*.

MANDIBLES (Pl. III, Figs. 24-35)

Mandibles are always flat and triangular. The lateral surface is thick and equipped with a distinct beaklike part, which serves as an attachment for the extensor muscle. The beaklike portion is distinct from the remaining lateral surface in all species except *Donacia flavipes*, in which it is a natural continuation of the lateral surface. Curvature of the lateral surface varies, being present to some extent in most species. In *D. flavipes* the lateral surface forms almost a straight line from the point of attachment of the extensor muscle to the proximal part of the outer tooth. There are always two apical teeth, which vary from round to pointed and also vary in their curvature. In most species studied the cutting surface is curved; in *D. flavipes*, however, it is approximately straight. Generally it has a definite concave region just proximad of the inner tooth. This region is serrate in some species and denticulate in others, with the exception of *D. cincticornis* and *D. proxima*, in which it is either denticulate or smooth. Each mandible has a round condyle, which is always on the basal portion of the ventral side. The basal border of the ventral side between the cutting edge and the condyle varies from straight to curved; when curved, it differs in the location of its concave and convex regions. There are always two setae present: one either on the lateral surface itself or on the beak portion of the lateral surface, the other always on the dorsal surface just distad of the neck of the condyle.

FRONTES (Pl. IV, Figs. 47-57)

The frons is always pentagonal. In general, it is not strongly sclerotized except for a band on the anterior edge which continues laterad to form the heavily sclerotized anterolateral border (Pl. IV, Fig. 48, *alb*). The posterolateral edges are without heavily sclerotized bands and unite to form an occipital region (Pl. IV, Fig. 48, *or*), which may be pointed or round, elongated or short. There are five angles: two anterior angles on the inner sides of the heavily sclero-

tized bands at the junctions of the anterior and the anterolateral bands; two lateral angles at the junctions of the anterolateral and posterolateral edges, the lateral ends of the anterolateral sclerotized bands filling a good portion of the angles; one occipital angle, which is formed at the union of the two posterolateral edges. Specific differences occur in the ratio of the distances between the lateral angles and between the occipital angle and mid-anterior point. In some species these distances are approximately equal; in others, one is longer. The occipital region varies in the different species in length and also in the sharpness of the point. The posterolateral margins can be used as specific characters because in the different species they vary from approximately straight to concave or convex. The heavily sclerotized anterolateral border varies in the different species from straight to deeply concave. In certain species the anterior angles differ greatly; in others they are constantly near either 100° or 120° .

LABRA (Pl. V, Figs. 58-68)

The labrum provides excellent specific characters. It is attached to the distal end of the clypeus, which in turn is attached to the anterior end of the frons. The shape of the labrum varies greatly among the species, although for some it is fairly uniform. There are five sides in all the species except *Donacia flavipes*, in which the lateral and anterior margins form a continuous curve. In *D. hirticollis* the labrum is only weakly five-sided. In the mid-region of the labrum there is a heavily sclerotized band, which bears on its ental surface an anteriorly curved process or hook. The extension of this band toward the posterior point of the labrum varies with the species. The labrum is furnished with sixteen setae, the arrangement and length of which serve as specific characters. Four pitlike structures occur on the dorsal face of the labrum. They have a definite position in some species, but may vary to a slight extent in others. These structures were called "sensory spots" by MacGillivray (1903). He also named the labral setae, and his terminology is used here, except for the addition of one term, namely, the "angular," as used by Böving (1910). Those setae which project from the anterior labral margin are called "marginal" setae; the one near the lateral margin, usually the longest, is the angular seta. In this paper the seta at the latero-anterior angle is designated as the angular, and the other setae in

succession medially are m^2 , m^3 , and m^4 (Pl. V, Fig. 59). Six "discal" setae project from the dorsal face of the labrum; two "proximal" setae are always closer to the caudal margin (Pl. V, Fig. 59, *ps*); two "distal" setae occur just caudad of the mid-anterior edge (Pl. V, Fig. 59, *ds*); there are two "medial" setae, each of which is laterad of the distal seta and mediad of the lateral seta (Pl. V, Fig. 59, *ms*). Two other setae, always near the lateral labral edges, are termed the "lateral" setae (Pl. V, Fig. 59, *ls*). In a very few specimens one pair of setae may be absent, or an additional pair may be present, which may be the reason why MacGillivray (1903) described two pairs of marginal setae in *Haemonia nigricornis*, although his figure shows three. In a few of the older larvae marginal setae may be worn or broken, a circumstance which causes difficulty in judging the length of the pairs. In all species except *D. flavipes* definite lateral wings, which may either project beyond the lateral surface or appear to be a continuation of it, are present at the caudal end of the lateral edge.

LACINIAE (Pl. VI, Figs. 69-79)

The lacinia is the only part of the maxilla that can be easily used for taxonomic purposes. The maxillae in the American Donaciini do not differ generally from those of the species discussed by Böving (1910). The lacinia is an ear-shaped projection from the anterior portion of the heavily sclerotized band of the stipes and is dorso-mediad of the palpus. The dorsal side is in the form of a niche (Pl. VI, Fig. 71, *nc*), which opens toward the mouth. On the medial side of the niche is a heavily sclerotized bow-shaped band (Pl. VI, Fig. 71, *bs*). This band bears two keel-shaped chitinous folds on its niche side and continues laterad as a thin sclerotized basin. The caudal part of the bow-shaped portion connects with the distal medial sclerotized band of the stipes. On the dorsolateral side of the niche there is a strongly sclerotized process, the chitinous process of Böving (1910), which is jagged at the posterior end and serves as a muscle attachment (Pl. VI, Fig. 71, *cp*). On the anterior end of the outer face of the chitinous process can be found two rows of hairlike projections (Pl. VI, Fig. 71, *hp*), the "emergence-clad portion" (Böving, 1910). These hairlike processes extend over the niche and obliquely cephalad. They do not occur in *Donacia flavipes*. At the anterior end of the bow-shaped band there is a needle-like structure (Pl. VI, Fig. 71, *ns*) united to the band by a joint. Ventral to the needle-

shaped structure is a soft scalpel-like blade which Böving (1910) suggests might be termed the "galea." Projecting into the niche and continuing along the side of the needle-shaped portion is a boot-shaped structure which is bifurcate, forming two setae. Böving (1910) discovered that the length of the needle-shaped portion compared to other parts of the lacinia is a good character for classification.

CHITINOUS BOWS OF LABIA (Pl. III, Figs. 36-46)

The chitinous bow is the only highly sclerotized region of the labium and is the one part showing enough variation to be used as a character for classification. In this paper the term "chitinous bow of labium" will be used as it is by Böving (1910). The chitinous bow is either semicircular or V-shaped.

CAUDAL SPINES (Pl. VI, Figs. 80-90)

The caudal spine consists of a base and a hook-shaped terminus. It is attached to the dorsum of the eighth abdominal segment. The base encloses a soft-walled oval space containing the spiracle, which is a slit elongated in an anteroposterior direction. The hook-shaped portion varies in length and curvature in the different species. The relation of the length of the hook to the soft-walled oval space makes an excellent character for separating *Donacia cincticornis*, *D. proxima*, and *D. piscatrix* from all other species. *D. proxima* and *D. palmata* (the latter described by MacGillivray, 1903) have serrations at the tip of the hook-shaped portion.

BODY SETAE (Pls. VII-X, Figs. 91-101)

The bodies of *Donaciini* larvae are covered with setae which vary in number and pattern in the species studied. For the purposes of this paper the terminology of the different groups of setae as used by MacGillivray (1903) has been adopted. He calls the groups of setae on the dorsum of each segment "tergal"; the anterior transverse row "anterior tergal" (Pl. VII, Fig. 91, *at*); the posterior row "posterior tergal" (Pl. VII, Fig. 91, *pr*); those above the spiracles and ventrad of the tergal groups "supraspiracular" (Pl. VII, Fig. 91, *ss*); and those below the spiracles "infraspiracular" (Pl. VII, Fig. 91, *is*); the "pedal" setae (Pl. VII, Fig. 91, *pds*) are those which surround the legs in the thorax and those found in a similar position in the abdomen; the "sternal" setae are those on the ventral side, which in the thoracic segments can be divided into "anterior"

(Pl. VII, Fig. 91, *ast*) and "posterior sternal" setae (Pl. VII, Fig. 91, *pst*), and in the abdominal segments can be divided along the mid-ventral line (Pl. VII, Fig. 91, *st*), but never transversely.

DESCRIPTIONS

Haemonia nigricornis Kirby

EGG (Pl. I, Fig. 1)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.20–1.46 mm.; average of 30 masses, 1.35 mm.; width, 0.51–0.69 mm.; average of 30 masses, 0.57 mm.

Shape. — Egg with gelatinous envelope elongate; gelatinous coat thick on sides of egg, often only on middle of top of egg. Gelatin-covered eggs, in groups, arranged in one row on inner sides of stipules of *Potamogeton natans*; long axes of envelopes parallel with or oblique to edge of stipule; envelopes usually in contact with one another.

Color. — Gelatinous envelopes distinctly yellow; ends of egg colorless when not covered by gelatinous substance.

Location. — Deposited on inner sides of submerged stipules of *Potamogeton natans*.

Egg

Size. — Length, 1.02–1.17 mm.; average of 30 eggs, 1.14 mm.; width, 0.36–0.47 mm.; average of 30 eggs, 0.42 mm. Length and width increasing during development.

Shape. — Elongate; both ends bluntly pointed; chorion thin, apparently smooth; micropyle not visible.

Color. — Yellow throughout development; colored yolk concentrated near middle of egg, ends clear; two rows of black ocelli appearing before hatching, three in front row and two in back.

Period of development. — Sixteen days.

LARVAE

General features (Pl. II, Fig. 13)

Eruciform; 8–11 mm. long at time of formation of cocoon; decreasing greatly in diameter anteriorly from second abdominal segment; abdominal segment 7 not greatly reduced in diameter, dorsal half of tergum broadly pointed, remaining portion of tergum flattened ventrally; abdominal segments 8, 9, and 10 short, capable of extend-

ing beyond apices of caudal spines; caudal spines projecting cephalad. Legs large. Green.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 24)

Flat, triangular, about as long as width of base. Two apical teeth, pointed, curving strongly toward cutting edge. Lateral surface curved, upper half convex and continuous with outer tooth, remaining surface to condyle approximately straight or weakly convex; beak portion serving as extensor muscle attachment, curving laterad and caudad, and often with a middle depression. Cutting edge curved, region just proximad of inner tooth a moderate to deep concavity, with large denticles lining concavity and base of inner tooth, middle third usually concave but sometimes straight, proximal third convex and ending in distinct hook. Border of basal end between condyle and cutting surface straight or curved; when curved having a middle convex portion and medial and lateral concavities.

Frons (Pl. IV, Fig. 47)

Pentagonal; distance between lateral angles approximating distance between occipital angle and mid-anterior point; posterolateral edge usually slightly shorter than distance between lateral angles, and approximately straight to occipital region; occipital point sharp but not elongated and narrow; anterior angles usually closer to 100° than to 120°, tip of angle often sharp; heavily sclerotized antero-lateral band curving strongly and evenly laterad. Eight long thin setae. Two pitlike structures.

Labrum (Pl. V, Fig. 58)

Five-sided; slightly less than twice as wide as long; pointed posterolateral wings projecting definitely laterad in posterior portion; remaining part of lateral sides oblique or curving to unite with anterior margin at bases of angular setae; anterior margin emarginate, generally with a long median concavity, small lateral concavities occurring at bases of angular setae, lateral concavities often appearing as part of lateral rather than of anterior border. Eight marginal setae; angular longest; angular, second, and third subequal in size; fourth usually as long as third; second marginal closer to angular than to third marginal; third and fourth pairs grouped,

usually equidistant and equal in length, sometimes distance between setae of fourth pair slightly greater than that between third and fourth pairs. Six discal setae; proximal longest; median setae lateral and posterior to distal, usually longer than angular; distal setae capable of extending to apices of third and fourth marginal setae. Two lateral setae, usually lateral to proximal and sometimes slightly anterior to them. Four pitlike structures; one pair posterior and often slightly lateral to distal setae; the other pair posterior and slightly lateral to proximal setae. All setae long and tapering evenly to a point. Heavily sclerotized band usually extending from bases of third and fourth marginal setae to a point between bases of proximal setae.

Lacinia (Pl. VI, Fig. 69)

Short; needle-shaped portion from one fifth to one third shorter than bow-shaped portion and slightly shorter to about one third shorter than region bearing hairlike projections; chitinous process more than twice as long as needle-shaped portion, occasionally three times as long.

Chitinous bow of labium (Pl. III, Fig. 36)

Semicircular; inner, posterior surface usually irregular.

Caudal spine (Pl. VI, Fig. 80)

Short; a line from posteroventral end of basal part to apex of hook one fifth to one third longer than basal part; hook-shaped portion five to six times as long as soft-walled oval space enclosing spiracle. Weakly curved, tapering evenly to blunt point.

Body setae (Pl. VII, Fig. 91)

Anterior tergal setae sparse, two to three rows of widely separated setae in central region of first six abdominal segments, sometimes four rows in segments 5 and 6, one to two rows in mesothorax and metathorax; three groups in mesothorax, metathorax, and first six abdominal segments, central groups separate or connected with lateral groups by one row; few setae in seventh, usually less than fifteen, often between five and twelve. Posterior tergal setae few and widely separated, one to three rows in mesothorax, metathorax, and first six abdominal segments; seventh segment with definite band of widely separated setae, larger number in central region. Supraspiracular

separated into two small groups in mesothorax and metathorax; sparse in all abdominal segments and usually forming a continuous group in first five segments, sometimes separated into two groups in sixth; not extending caudad of anterior row of posterior tergal band in first five abdominal segments; separated from or connected with anterior tergal band in first six abdominal segments by one row, not connected with anterior tergal in seventh; sparse in seventh, usually less than six, often between one and four; not connected with posterior tergal band. Infraspicular not numerous; separated into two groups or composing one continuous group in mesothorax and metathorax; united with posterior tergal and pedal setae in seventh abdominal. Pedal setae not numerous. Anterior sternal of mesothorax and metathorax usually sparse; generally not in definite row; not coalesced with posterior sternal. Posterior sternal sparse; two groups in mesothorax and metathorax. Abdominal sternal few; narrowed in central portion of all segments, often separated into two groups in segments 3 through 7. All tergal setae long but not stout, those of sixth and seventh exceptionally long; sternal setae small, often not easily seen.

Donacia piscatrix Lacordaire

EGG (Pl. I, Fig. 2)

Egg mass

Shape. — Eggs with gelatinous envelopes forming irregular mass; individual gelatinous envelopes distinct from one another; secondary grooves on each gelatinous envelope.

Color. — Gelatinous envelopes yellow; opaque, eggs not visible through envelopes.

Location. — Deposited on submerged part of peduncle of *Nymphaea advena*.

Egg

Size. — Length, 0.73–0.87 mm.; average of 30 eggs, 0.82 mm.; width, 0.32–0.36 mm.; average of 30 eggs, 0.34 mm. Length and width increasing with development.

Shape. — Elongate; one end bluntly rounded and other bluntly pointed; chorion thin, apparently smooth; micropyle not visible.

Color. — Light cream to white when first laid; yolk filling entire egg; before hatching changing to light yellow; two rows of brown

to black ocelli appearing before hatching, three in front row and one or two, usually one, in back.

Period of development. — Sixteen days.

LARVAE

General features (Pl. II, Fig. 14)

Eruciform; 12–16 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 long and tapering, when fully extended capable of protruding beyond apices of caudal spines; caudal spines projecting ventrad or caudad. Legs of moderate size. White.

Ocelli

Four or five; two rows, three in front row and one or two, usually one, in back; black.

Mandible (Pl. III, Fig. 25)

Flat, triangular, about as long as width of base. Two apical teeth, bluntly pointed, curving strongly toward cutting edge. Lateral surface curved, upper third convex and continuous with outer tooth, remaining surface to condyle varying with curved and straight parts; beak portion serving as extensor muscle attachment, curving laterad and caudad. Cutting edge curved, region just proximad of inner tooth a long deep concavity with large denticles lining concavity and basal half of inner tooth, region proximad of serrate concavity varying from straight to convex but usually convex in basal third. Border of basal end between condyle and cutting surface curved, cutting half concave, condyle half convex.

Frons (Pl. IV, Fig. 48)

Pentagonal; distance between lateral angles usually slightly shorter than distance between occipital angle and mid-anterior point, sometimes distinctly shorter; posterolateral edge generally approximating distance between lateral angles, sometimes slightly longer, and usually concave to occipital region; occipital point elongated and narrow; anterior angles variable in width; heavily sclerotized antero-lateral band usually bending strongly laterad. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 59)

Five-sided; from about one and one-half to two times as wide as long; short posterolateral wings projecting slightly laterad; remaining part of lateral sides curving to unite with anterior margin below proximal ends of angular setae, often evenly curved; anterior margin with middle shallow depression varying in length, sometimes with slight indentation at base of angular seta. Eight marginal setae; angular longest; angular, second and third subequal in size; fourth sometimes as long as third; second marginal closer to angular than to third marginal; distance between fourth marginal setae greater than that between third and fourth pairs. Six discal setae; proximal longest; median setae lateral and slightly posterior to distal; distal setae short, usually not capable of extending to apices of third marginal, generally projecting upright. Two lateral setae; lateral and in line with or slightly anterior to proximal. Four definite pitlike structures; one pair usually between and in line with medial and distal setae, generally closer to distal than to medial; the other pair often lateral and slightly posterior to proximal setae; one additional pair sometimes between bases of second and third marginal setae, but when present not clearly visible. All setae tapering gradually from base to point, third and fourth pairs needle-like. Heavily sclerotized band extending from mid-posterior edge to insertion of fourth marginal setae.

Lacinia (Pl. VI, Fig. 70)

Elongate; needle-shaped portion approximately one fourth longer than bow-shaped portion and usually more than one third longer than region bearing hairlike projections; chitinous process one fifth to one fourth longer than needle-shaped portion.

Chitinous bow of labium (Pl. III, Fig. 37)

Semicircular; usually one elongated low posterior projection and two lateral swellings.

Caudal spine (Pl. VI, Fig. 81)

Elongate; a line from posteroventral end of basal part to apex of hook about three times as long as length of basal part, usually slightly shorter; hook-shaped portion nine to ten times as long as soft-walled oval space enclosing spiracle. Strongly curved, tapering evenly to pointed tip.

Body setae (Pl. VII, Fig. 92)

Anterior tergal setae moderate in number, about three to six rows in first six abdominal segments, about two to four rows in mesothoracic and metathoracic segments; three definite groups in mesothoracic, metathoracic, and first six abdominal segments, central groups separate or connected with lateral groups by one row of setae in first six abdominal segments, usually separated in mesothorax and metathorax; a few widely separated or centrally massed setae in seventh abdominal segment, usually fewer than twenty, often between ten and eighteen. Posterior tergal setae moderate in number, about three to five rows in mesothorax, metathorax, and first seven abdominal segments, sometimes fewer in mesothorax, metathorax, and seventh abdominal segment, only one to three rows in lateral extremities in first six abdominal segments; not connected with anterior tergal band in mesothorax and metathorax; sometimes continuing cephalad with one row in seventh abdominal segment. Supraspiracular groups separated in mesothorax and metathorax; elongate and not divided in first six abdominal segments; usually not extending posterior beyond anterior row of lateral extremities of posterior tergal band in abdominal segments; first six abdominal groups usually not coalescing with anterior tergal band, occasionally some segments coalesced by one row of setae; seventh generally not coalesced with anterior tergal group; number reduced in seventh abdominal segment, usually fewer than five setae, often one to four. Infraspiracular of mesothorax and metathorax generally not divided into two groups, when divided, posterior group containing but a few; number often gradually reducing in fifth, sixth, and seventh abdominal segments. Usually slightly fewer pedal setae in fifth, sixth, and seventh abdominal segments. Anterior sternal group of mesothorax broken or continuous and not coalesced with posterior sternal group; coalesced or weakly separated in the metathorax and separate or united to posterior sternal by one or two rows of setae. Posterior sternal in two separated groups or united at anterior ends in mesothorax; usually united in anterior portion in metathorax. Sternal group narrowed or separated in fourth abdominal segment; separated into two groups in fifth, sixth, and seventh abdominal segments, in a few instances narrowed in fifth.

Donacia proxima Kirby

EGG (Pl. I, Fig. 3)

Egg mass

Shape. — Eggs with gelatinous envelopes arranged in double row around hole in leaf; outer and attached surfaces flat; gelatinous envelopes arranged in two distinct rows; secondary grooves on each envelope.

Color. — Gelatinous envelopes white; opaque, eggs not visible.

Location. — Deposited on under side of leaf of *Nymphaea advena*.

Egg

Size. — Length, 0.91–0.98 mm.; average of 30 eggs, 0.97 mm.; width, 0.36–0.40 mm.; average of 30 eggs, 0.37 mm. Length and width increasing with development.

Shape. — Elongate; ends bluntly rounded; chorion thin, apparently smooth; micropyle not visible.

Color. — Pale yellow when first laid; yolk filling almost entire egg; before hatching changes to distinct yellow; two rows of brown to black ocelli appearing before hatching, three in front row and two in back.

Period of development. — Sixteen days.

LARVAE

General features (Pl. II, Fig. 15)

Eruciform; 12–16 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 long and tapering, when fully extended capable of protruding beyond apices of caudal spines; caudal spines projecting ventrad or caudad. Legs of moderate size. White.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 26)

Flat, triangular, slightly longer than width of base. Two apical teeth, bluntly pointed, curving strongly toward cutting edge. Lateral surface curved, upper half usually convex and continuous with outer tooth, remaining surface to condyle varying with curved and straight portions; beak part serving as extensor muscle attachment, curving

laterad and caudad. Cutting edge curved, region just proximad of inner tooth a long deep concavity either smooth or with large denticles, region proximad of concavity usually composed of two convex regions. Border of basal end between condyle and cutting surface curved, cutting third concave, condyle two thirds straight to convex.

Frons (Pl. IV, Fig. 49)

Pentagonal; distance between lateral angles usually slightly shorter than distance between occipital angle and mid-anterior point, sometimes distinctly longer; posterolateral edge generally approximating distance between lateral angles, sometimes distinctly shorter, and usually concave to occipital region, sometimes straight; occipital point generally elongated and narrow, occasionally only slightly narrowed; anterior angles variable in width; heavily sclerotized antero-lateral band usually bending strongly laterad. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 60)

Five-sided; from about one and one-half to two times as wide as long; posterolateral wings generally broadly rounded and projecting laterad; remaining part of lateral sides curving to unite with anterior margin below proximal ends of angular setae, strongest curve usually just lateral to base of angular seta; anterior margin with middle, moderately deep depression of variable length, sometimes with slight indentation at base of angular seta. Eight marginal setae; angular longest; angular and second subequal in size; third sometimes as long as second; fourth sometimes as long as third; second marginal closer to angular than to third marginal; distance between setae of fourth marginal pair greater than that between third and fourth pairs. Six discal setae; proximal longest; median setae varying from directly lateral to lateral and slightly anterior or posterior to distal setae; distal setae long, usually capable of extending beyond the apices of the third marginal, projecting in an anterior direction. Two lateral setae, lateral and in line with or slightly anterior to proximal. Usually six pitlike structures; one pair varying from posterior to lateral to distal setae (sometimes one additional pair in this region); one pair posterior and slightly lateral to proximal setae; one pair ordinarily between bases of second and third marginal setae. Third and fourth marginal setae usually stout, blunt to pointed, generally tapering strongly only in distal half, sometimes reduced

to stubs because of breakage or wear. Heavily sclerotized band extending from mid-posterior edge to insertion of fourth marginal setae.

Lacinia (Pl. VI, Fig. 71)

Elongate; needle-shaped portion one fourth to one third longer than bow-shaped portion and usually more than one third longer than region bearing hairlike projections; chitinous process one fourth to one third longer than needle-shaped structure.

Chitinous bow of labium (Pl. III, Fig. 38)

Semicircular; usually one posterior bluntly pointed projection of moderate size.

Caudal spine (Pl. VI, Fig. 82)

Elongate; a line from posteroventral end of basal part to apex of hook about three times as long as length of basal part; hook-shaped portion ten to twelve times as long as soft-walled oval space enclosing spiracle. Moderately curved, tapering evenly; tip serrate on inner edge.

Body setae (Pl. VII, Fig. 93)

Anterior tergal setae numerous, about five to seven rows in metathorax and first six abdominal segments, sometimes slightly fewer in metathorax, two to four rows in mesothorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, central groups connected with lateral groups by one or two rows of setae in first six abdominal segments, separated or connected in mesothorax and metathorax; usually less than twenty widely separated setae in seventh abdominal segment, often between ten and fifteen. Posterior tergal setae numerous, about five to seven rows in mesothorax, metathorax, and first seven abdominal segments, sometimes fewer in mesothorax, metathorax, and seventh abdominal segment, only two or three rows in lateral extremities; usually not connected with anterior tergal in mesothorax and metathorax but sometimes connected by one row. Supraspiracular groups separated in mesothorax and metathorax; not divided in first six abdominal segments; usually not extending posterior to anterior row of lateral extremities of posterior tergal band; first six abdominal groups usually coalescing with anterior tergal band, sometimes weakly separated in third, fourth, fifth, and sixth segments; seventh usually not coalesce with

anterior or posterior tergal band; fewer setae in seventh abdominal, usually less than six. Infraspicular of mesothorax and metathorax usually divided into two groups, fused or separated; number often gradually decreasing in fifth, sixth, and seventh abdominal segments. Generally fewer pedal setae in seventh abdominal segment. Anterior sternal usually continuous in mesothorax and not coalesced with posterior sternal group; separated or coalesced in metathorax and usually united with posterior sternal by one or two rows of setae. Posterior sternal generally in two separated groups in mesothorax; usually united in anterior portion of metathorax. Sternal of fourth abdominal segment sometimes narrowed; those of fifth generally separated into groups, sometimes only narrowed in mid-ventral line; those of sixth and seventh separated into groups.

Donacia cincticornis Newman

Egg (Pl. I, Fig. 4)

Egg mass

Size. — Width of double row of eggs, 2.50–3.33 mm.; average of 30 masses, 3.15 mm.; length varying with number of eggs.

Shape. — Eggs in gelatinous matrix arranged in double row around hole in leaf; outer surface of matrix convex, attached surface flat; no apparent demarcation between individual gelatinous envelopes in each row but individual envelopes can be separated by dissection.

Color. — Gelatinous matrix translucent, with two rows of cream-colored eggs showing through.

Location. — Deposited on under side of leaf of *Castalia odorata*.

Egg

Size. — Length, 0.84–0.95 mm.; average of 30 eggs, 0.90 mm.; width, 0.32–0.40 mm.; average of 30 eggs, 0.36 mm. Length and width increasing with development.

Shape. — Elongate; ends bluntly rounded, curving more strongly on one side than on other; chorion thin, apparently smooth; micropyle not visible.

Color. — Cream when first laid, ends clear; changing to yellow before hatching; two rows of brown to black ocelli appearing before hatching, three in front row and two in back.

Period of development. — From 12 to 13 days.

LARVAE

General features (Pl. II, Fig. 16)

Eruciform; 11–15 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 long and tapering, when fully extended capable of protruding beyond apices of caudal spines; caudal spines projecting ventrad or caudad. Legs of moderate size. White.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 27)

Flat, triangular, about as long as width of base. Two apical teeth, usually rounded but sometimes bluntly pointed, curving strongly toward cutting edge. Lateral surface curved, upper third convex and continuous with outer tooth, remaining part of surface to condyle varying with curved and straight portions; beak portion serving as extensor muscle attachment, curving laterad and caudad. Cutting edge curved, region just proximad of inner tooth a long deep concavity either entirely smooth or with distinct elongated denticles, region proximad of concavity varying from straight to convex but usually convex in basal third. Border of basal end between condyle and cutting surface varying from unevenly straight to curved, when curved cutting half concave and condyle half slightly convex.

Frons (Pl. IV, Fig. 50)

Pentagonal; distance between lateral angles distinctly longer than distance between occipital angle and mid-anterior point, often one fifth longer; posterolateral edge distinctly shorter than distance between lateral angles and usually approximately straight to occipital region; occipital point sharp but not elongated and narrow; anterior angles variable in width, tip of angle often sharp; heavily sclerotized anterolateral band usually curving moderately and evenly laterad. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 61)

Five-sided; from about one and one-half to two times as wide as long; posterolateral wings usually not projecting laterad, often lobed; remaining part of lateral sides usually straight and frequently lobed, sometimes curved; anterior margin emarginate, with a mod-

crate to deep middle depression, two lateral indentations at bases of angular and second marginal setae. Eight marginal setae; angular longest; angular, second, and third subequal, fourth sometimes as long as third; second marginal closer to angular than to third; distance between setae of fourth marginal pair greater than that between third and fourth pairs. Six discal setae; proximal longest, median setae varying from directly lateral to lateral and slightly anterior or posterior to distal setae; distal setae long, usually capable of extending to or beyond apices of fourth marginal, projecting in an anterior direction. Two lateral setae; lateral and in line with or slightly anterior to proximal. Usually six pitlike structures; one pair lateral to distal and usually in line with medial; one pair posterior and lateral to proximal; one pair usually between bases of second and third marginal setae. Marginal setae stout, angular and second often tapering only in distal two thirds, third and fourth blunt to pointed and generally tapering only in distal half, third and fourth sometimes reduced to stubs because of breakage or wear. Heavily sclerotized band extending from mid-posterior edge to insertion of fourth marginal setae.

Lacinia (Pl. VI, Fig. 72)

Elongate; needle-shaped portion approximately one fourth longer than bow-shaped portion and about one third longer than region bearing hairlike projections; chitinous process about one fifth to one fourth longer than needle-shaped structure.

Chitinous bow of labium (Pl. III, Fig. 39)

Semicircular; usually one small posterior pointed projection.

Caudal spine (Pl. VI, Fig. 83)

Elongate; a line from posteroventral end of basal part to apex of hook three or more times as long as length of basal part; hook-shaped portion nine to eleven times as long as soft-walled oval space enclosing spiracle. Weakly curved, tapering evenly to wedge-shaped point.

Body setae (Pl. VIII, Fig. 94)

Anterior tergal setae numerous, about five to seven rows in metathorax and first six abdominal segments, two to four rows in mesothorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, central groups connected with lateral

groups by one or two rows of setae in first six abdominal segments, separated or connected in mesothorax and metathorax but usually separated in mesothorax; more than twenty setae in seventh abdominal segment, one definite band with an increased number in mid-dorsal area. Posterior tergal setae numerous, about four to seven rows in mesothorax, metathorax, and first seven abdominal segments, only two or three rows in lateral extremities; usually not connected with anterior tergal in mesothorax and metathorax, sometimes connected by one row. Supraspiracular groups divided in mesothorax and metathorax; not divided in first six abdominal segments; generally not extending posterior to anterior row of lateral extremities of posterior tergal band; first six abdominal groups usually coalescing with anterior tergal band, sometimes weakly separated in third, fourth, fifth, and sixth segments; seventh usually not coalesced with anterior tergal group, sometimes connected; seventh sometimes connected with posterior tergal band by one row of setae; fewer setae in seventh abdominal segment, generally less than ten. Infraspiracular of mesothorax and metathorax usually not separated into two groups, if separated posterior group composed of few setae; number often gradually decreasing in fifth, sixth, and seventh abdominal segments. Usually fewer pedal setae in seventh abdominal segment. Anterior sternal generally continuous in mesothorax and not coalesced with posterior sternal group; separated or coalesced in metathorax and usually united with posterior sternal by one or two rows of setae. Posterior sternal generally in two separated groups in mesothorax; usually united in anterior portion of metathorax. Sternal of fifth abdominal usually narrowed in mid-ventral line, sometimes separated into two groups; always separated into two groups in sixth and seventh abdominal segments.

Donacia hirticollis Kirby

EGG (Pl. I, Fig. 7)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.06–1.39 mm.; average of 30 masses, 1.20 mm.; width, 0.47–0.58 mm.; average of 30 masses, 0.51 mm.

Shape. — Egg with gelatinous envelope elongate; one end of envelope rounded, one end often with short gelatinous tail; upper and lower gelatinous surfaces attached between submerged leaves

or submerged plant stem and its stipules. Gelatin-covered eggs, in groups, deposited in an irregular mass; long axes of envelopes usually leaning at an angle to edge of leaf or stipule but tending to be parallel with it.

Color. — Gelatinous envelopes translucent to opaque; white; coat over top of egg usually thick enough to give white appearance to whole mass when viewed with naked eye.

Location. — Collected from between stem and stipules of *Potamogeton natans* and between submerged parts of two *Sparganium angustifolium* leaves.

Egg

Size. — Length, 0.91–1.09 mm.; average of 30 eggs, 0.99 mm.; width, 0.36–0.43 mm.; average of 30 eggs, 0.40 mm. Width increasing with development.

Shape. — Elongate; one end bluntly rounded, other end bluntly pointed; chorion thin, apparently smooth; micropyle not visible.

Color. — Cream throughout development; colored yolk concentrated near middle; two rows of black ocelli appearing before hatching, three in front row and two in back.

Period of development. — Twelve days.

LARVAE

General features (Pl. II, Fig. 17)

Eruciform; 12–14 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 short, capable of protruding beyond apices of caudal spines; caudal spines projecting ventrad. Legs of moderate size. Usually light gray.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 28)

Flat, triangular, longer than width of base. Two apical teeth, bluntly pointed, curving weakly toward cutting edge. Lateral surface curved in distal third and continuous with outer tooth, remaining surface nearly straight to base of condyle; beak portion serving as extensor muscle attachment, slanting obliquely laterad in proximal two thirds. Cutting edge curved, distal two thirds usually straight,

proximal third convex and ending in a distinct hook; region just proximad and including inner tooth having large denticles. Border of basal end between condyle and cutting border curved, with a middle convex portion, a median indentation, and a lateral concavity.

Frons (Pl. IV, Fig. 51)

Pentagonal; distance between lateral angles equal to or slightly longer than distance between occipital angle and mid-anterior point; posterolateral edge equal to or slightly shorter than distance between lateral angles and approximately straight, often with slight convex region in middle; occipital region round to bluntly pointed and not greatly narrowed; anterior angles closer to 120° than 100° ; heavily sclerotized anterolateral band generally bending strongly laterad, straight to weakly curved. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 62)

Weakly five-sided; from one and one-half to two times as wide as long; posterolateral wing continuous with remaining part of lateral surface; union of anterior and lateral margins not distinct; usually a shallow to deep depression in region of second, third, and fourth pairs of marginal setae. Eight marginal setae; angular longest; setae of second, third, and fourth pairs equal in size and equidistant; distance between setae of fourth pair usually slightly greater than that between third and fourth pairs, sometimes the same. Six discal setae; proximal longest; median lateral and varying from posterior to anterior to distal, grouped with angular and lateral; distal setae generally not capable of extending to anterior margin, usually projecting upright. Two lateral setae, lateral and slightly posterior to medial setae. Four pitlike structures; one pair between distal and proximal setae; the other pair posterior and lateral to proximal setae. All setae tapering gradually from base to point; second, third, and fourth sometimes stout and blunt but still tapering evenly. Heavily sclerotized band usually extending from bases of fourth marginal setae to a point slightly posterior to bases of distal setae.

Lacinia (Pl. VI, Fig. 73)

Short; needle-shaped portion one fourth to one third shorter than bow-shaped portion and slightly shorter than region bearing hairlike projections; chitinous process over twice as long as needle-shaped structure, occasionally three times as long.

Chitinous bow of labium (Pl. III, Fig. 40)

Semicircular; inner posterior and inner lateral surfaces usually irregular.

Caudal spine (Pl. VI, Fig. 84)

Short; a line from posteroventral end of basal part to apex of hook slightly longer to one fourth longer than length of basal part; hook-shaped portion three to four times as long as soft-walled oval space enclosing spiracle. Moderately curved, thick at base, narrowed to sharp point at apex.

Body setae (Pl. VIII, Fig. 95)

Anterior tergal setae numerous, about five to seven rows in mesothorax, metathorax, and first six abdominal segments; three groups in mesothorax, metathorax, and first six abdominal segments, central groups connected with lateral groups by one to two rows in mesothorax and metathorax, one to three rows in first six abdominal segments; setae sparse in seventh, usually less than twenty, often between eight and sixteen. Posterior tergal setae numerous and widely separated, about four to six rows in mesothorax, metathorax, and first seven abdominal segments; definitely coalesced with anterior tergal band and usually with suprspiracular group in mesothorax and metathorax, sometimes coalesced with anterior tergal by one row in metathorax. Suprspiracular divided and often separated into two groups in mesothorax and metathorax; numerous widely separated setae in first six abdominal segments; groups extending caudad to posterior row of posterior tergal band in first six abdominal segments; coalescing with posterior tergal band in sixth abdominal segment, sometimes coalescing in first five abdominal segments; widely coalesced with anterior tergal band in first six abdominal segments, not coalesced in seventh; setae sparse in seventh, usually less than eight, often between two and six; usually not coalescing with posterior tergal band in seventh. Infrspiracular usually not divided in mesothorax and metathorax; often fewer in seventh abdominal segment; sometimes fused with posterior tergal band in seventh. Fewer pedal setae in seventh abdominal segment; coalesced with some or all sternal groups in first six abdominal segments. Anterior sternal not numerous in mesothorax and metathorax, two to three rows in central region, sometimes a few setae caudad to third row; not coalesced with posterior sternal groups. Posterior sternal

of mesothorax and metathorax in two separated groups or united at anterior ends. Sternal of seventh abdominal segment separated into two groups or continuous. Usually all setae long and stout, sometimes only those of fifth and sixth abdominal segments.

Donacia pubescens Le Conte

Egg (Pl. I, Fig. 6)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.24–1.39 mm.; average of 30 masses, 1.29 mm.; width, 0.43–0.58 mm.; average of 30 masses, 0.51 mm.

Shape. — Egg with gelatinous envelope elongate; envelope usually not extended into long gelatinous tail; gelatinous coat very thin over top of egg and thin at sides. Gelatin-covered eggs, in groups, arranged in single row on inner sides of submerged outer culm sheaths; long axes of envelopes usually parallel to edge of sheath; envelopes generally end to end.

Color. — Gelatinous envelopes translucent; white; coat over top of egg thin enough to give differentiation between egg and gelatinous sides of envelope when viewed with naked eye.

Location. — Deposited on inner sides of outer culm sheaths of *Scirpus occidentalis*.

Egg

Size. — Length, 0.98–1.13 mm.; average of 30 eggs, 1.08 mm.; width, 0.36–0.43 mm.; average of 30 eggs, 0.39 mm. Width increasing with development.

Shape. — Elongate; one end bluntly rounded, other end bluntly pointed; upper side of egg convex, under side straight; chorion thin, apparently smooth; micropyle not visible.

Color. — Cream throughout development, ends clear; two rows of black ocelli appearing before hatching, two in front row and two in back.

Period of development. — From 11 to 12 days.

LARVAE

General features (Pl. II, Fig. 18)

Eruciform; short, 9–11 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from

middle of body; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad or cephalad. Legs of moderate size. Usually cream-colored.

Ocelli

Four; two rows, two in front row and two in back; black.

Mandible (Pl. III, Fig. 29)

Flat, triangular, about as long as width of base. Two apical teeth, bluntly pointed, outer one curving strongly toward cutting edge, inner edge of inner tooth not curving greatly medially of cutting border, sometimes inner tooth rounded at apex. Lateral surface curved, upper half convex and continuous with outer tooth, remaining surface to condyle varying with convex and concave portions; beak portion serving as extensor muscle attachment, curving laterad and caudad, usually with a middle notch. Cutting edge curved, distal half straight to slightly concave with low denticles or serrate ridge just proximad of inner tooth, proximal half usually convex. Border of basal end between condyle and cutting surface curved, having a middle convex portion with lateral and median concavities.

Frons (Pl. IV, Fig. 52)

Pentagonal; distance between lateral angles approximating distance between occipital angle and mid-anterior point; posterolateral edge usually slightly shorter than distance between lateral angles, sometimes as long, and approximately straight to occipital region; occipital region pointed and slightly narrowed; anterior angle closer to 100° than 120°, tip of angle often rounded; heavily sclerotized anterolateral band curving weakly laterad. Eight long stout setae. Two pitlike structures.

Labrum (Pl. V, Fig. 63)

Five-sided; from about one and one-half to two times as wide as long; posterolateral wings projecting laterad and continuing down to bases of medial setae; remaining part of lateral sides oblique or curving to unite with anterior border lateral to bases of angular setae; mid-posterior projection moderate in length; anterior margin emarginate, definite depression within second marginal setae; usually a slight depression at bases of angular setae. Eight marginal setae; angular longest; second generally slightly longer than third; fourth equal to or smaller than third; second closer to third than to angular;

third usually closer to fourth than to second; distance between setae of fourth pair generally greater than that between third and fourth pairs, sometimes the same. Six discal setae; proximal longest; medial approximately lateral to distal; distal capable of extending beyond apices of third and fourth marginal. Two lateral setae, lateral and usually slightly anterior to proximal. Four pitlike structures; one pair posterior and slightly lateral to distal setae; the other pair posterior and slightly lateral to proximal setae. All setae stout, tapering gradually to a point; second, third, and fourth marginal sometimes blunt but still tapering evenly. Heavily sclerotized band extending from point between proximal setae to insertion of fourth marginal setae.

Lacinia (Pl. VI, Fig. 74)

Short; needle-shaped portion usually about one third shorter than bow-shaped portion and generally slightly shorter than region bearing hairlike projections; chitinous process from one and one half to two times as long as needle-shaped structure.

Chitinous bow of labium (Pl. III, Fig. 41)

Semicircular; posterior part generally thick; usually without irregularities.

Caudal spine (Pl. VI, Fig. 85)

Short; a line from posteroventral end of basal part to apex of hook about one fourth to one third longer than length of basal part; hook-shaped portion four to five times as long as soft-walled oval space enclosing spiracle. Moderately thick, weakly curved, tapering evenly to point.

Body setae (Pl. VIII, Fig. 96)

Anterior tergal setae moderate in number, about three to five rows in first seven abdominal segments, about two to four rows in mesothorax and metathorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, central groups separate or connected with lateral groups by one row of setae, sometimes connected by two rows in sixth abdominal segment; a definite band of setae in seventh abdominal segment, usually more than thirty, often between thirty-five and fifty. Few posterior tergal setae, about two continuous rows and often an interrupted third row in meso-

thorax, metathorax, and first four abdominal segments, often three or four rows in fifth and sixth segments; seventh with a definite band having an increased number of setae in central region; usually not connected with anterior tergal band in mesothorax and metathorax, sometimes connected by one row. Supraspiracular separated in mesothorax and metathorax; usually divided into two groups in first six abdominal segments, separated or connected by one row of setae, sometimes connected by more than one row in a few segments; not projecting caudad of anterior row of posterior tergal band in first five abdominal segments, sometimes projecting beyond this row in sixth; coalescing with anterior tergal band in all segments; usually ten or more setae in seventh; coalescing with posterior tergal in seventh. Infraspiracular separated or weakly joined in mesothorax and metathorax; number not greatly reduced in seventh abdominal. Number of pedal setae reduced or not reduced in seventh; often coalesced with abdominal sternal in some or all segments. Anterior sternal of mesothorax and metathorax composed of a continuous band of two or three rows of setae; coalesced with posterior sternal, joined definitely in central region of posterior sternal or over its entire width. Posterior sternal in two groups or one continuous group, when in two groups connected at anterior ends. Sternal of seventh abdominal divided; sixth not narrowed. Setae stout and often long.

Donacia quadricollis Say

EGG (Pl. I, Fig. 10)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.24–1.83 mm.; average of 30 masses, 1.49 mm.; width, 0.58–0.73 mm.; average of 30 masses, 0.64 mm.

Shape. — Egg with gelatinous envelope elongate; envelope extended at one end as pointed gelatinous tail; gelatinous coat moderately thin over top of egg, thick at sides. Gelatin-covered eggs, in groups, arranged in single row on inner sides of submerged inner culm sheaths; long axes of envelopes leaning at an angle to edge of sheath and tending to be perpendicular to it.

Color. — Gelatinous envelope translucent; white; coat over top of egg thick enough to give white appearance to whole mass when viewed with naked eye.

Location. — Deposited on inner sides of inner culm sheaths of *Scirpus occidentalis*.

Egg

Size. — Length, 0.98–1.17 mm.; average of 30 eggs, 1.09 mm.; width 0.43–0.54 mm.; average of 30 eggs, 0.48 mm. Length increasing, width decreasing with development.

Shape. — Elongate; one end bluntly rounded, other end bluntly pointed; upper side of egg convex, under side straight; chorion thin, apparently smooth; micropyle not visible.

Color. — Cream throughout development; yolk filling entire egg; two rows of black ocelli appearing before hatching, three in front row and two in back.

Period of development. — From 12 to 13 days.

LARVAE

General features (Pl. II, Fig. 19)

Eruciform; of moderate size, 12–13 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body, sixth abdominal segment not greatly reduced; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad. Legs of moderate size. White.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 30)

Flat, triangular, about as long as width of base. Two apical teeth, outer one bluntly pointed or round and curving weakly toward cutting edge, inner one usually short and round but sometimes bluntly pointed, point of inner tooth usually not projecting beyond cutting surface. Lateral surface curved, upper half convex and continuous with outer tooth, remaining surface to base of condyle not distinct; beak portion serving as extensor muscle attachment, curving laterad and caudad. Cutting edge curved, region just proximal of inner tooth a long, shallow concavity with only a serrate ridge, proximal one third to one half usually strongly convex. Border of basal end between condyle and cutting surface curved, median portion convex with median and lateral concavities.

Frons (Pl. IV, Fig. 53)

Pentagonal; distance between lateral angles usually distinctly longer than distance between occipital angle and mid-anterior point; posterolateral edge noticeably shorter than distance between lateral angles and usually irregularly convex, sometimes approximately straight; occipital region slightly narrowed and generally acutely rounded; anterior angles usually closer to 120° than 100° , tip of angle often rounded; heavily sclerotized anterolateral band projecting strongly laterad, curving moderately to weakly. Eight long stout setae. Two pitlike structures.

Labrum (Pl. V, Fig. 64)

Five-sided; from one and one-half to two times as wide as long; posterolateral wings projecting slightly laterad; remaining part of lateral sides oblique or curved and uniting with anterior border just lateral to bases of angular setae; mid-posterior projection long; anterior margin emarginate, usually a definite depression in region of second, third, and fourth marginal setae, generally a slight depression at bases of angular setae. Eight marginal setae; angular longest; second, third, and fourth of equal size and usually equidistant, sometimes distance between second and third slightly greater than that between third and fourth; distance between setae of fourth pair usually greater than that between third and fourth pairs, sometimes the same. Six discal setae; proximal longest; median approximately lateral to distal setae; distal setae usually capable of extending beyond apices of fourth marginal setae, generally projecting in an anterior direction. Two lateral setae, lateral and often anterior to proximal. Four pitlike structures; one pair posterior and lateral to distal setae; the other pair posterior to proximal setae. All setae stout, tapering gradually to a point; second, third, and fourth sometimes blunt but still tapering gradually. Heavily sclerotized band extending from insertion of fourth marginal setae to a point between proximal pitlike structures.

Lacinia (Pl. VI, Fig. 75)

Short; needle-shaped portion one fifth to one fourth shorter than bow-shaped portion and approximately as long as region bearing hairlike projections; chitinous process approximately twice as long as needle-shaped portion.

Chitinous bow of labium (Pl. III, Fig. 42)

Semicircular to weakly V-shaped; usually without irregularities.

Caudal spine (Pl. VI, Fig. 86)

Short; a line from posteroventral end of basal part to apex of hook slightly longer to about one third longer than length of basal part; hook-shaped portion four to five times as long as soft-walled oval space enclosing spiracle. Weakly curved, tapering evenly to sharp point.

Body setae (Pl. IX, Fig. 97)

Anterior tergal setae moderate in number, about three to five rows in first six abdominal segments, two to three rows in mesothorax and metathorax, sometimes four in metathorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, central groups separate or connected with lateral groups by one row of setae, usually separated in mesothorax and metathorax; a definite band of setae in seventh abdominal, usually more than fifteen, often between twenty and thirty. Posterior tergal setae moderate in number, two to three rows of setae in mesothorax and metathorax, two to four rows forming a regular or irregular band in first six abdominal segments; seventh segment having a definite band with an increased number in central region, turning cephalad in lateral extremities; usually not connected with anterior tergal band in mesothorax and metathorax, sometimes connected by one row. Supraspiracular separated in mesothorax and metathorax; usually a continuous group in first four abdominal segments, often not narrowed in middle of first four, sometimes setae of one or two segments of the first four lobed, sometimes lobed or separated in two groups in fifth and sixth segments; often extending to anterior row of posterior tergal band in first five abdominal segments, frequently projecting to posterior row of posterior tergal band and sometimes fusing with latter in sixth segment; usually coalescing with anterior tergal band in first six abdominal segments, separated from anterior tergal band in seventh; setae sparse in seventh, usually less than ten, often between six and eight; seventh segment usually coalescing with posterior tergal band. Infraspicular divided into two groups in mesothorax and metathorax, separated or connected, generally slightly fewer in seventh segment. Usually fewer pedal setae in seventh abdominal segment; generally not connected with abdomi-

nal sternal. Anterior sternal of mesothorax and metathorax a continuous band or separated groups; few setae, not more than three rows, often one row; not coalesced with posterior sternal groups. Posterior sternal in two separated groups in mesothorax and metathorax, sometimes sparse. Sternal of seventh abdominal separated into two groups; usually narrowed or separated in sixth, sometimes not narrowed. Setae of moderate length.

Donacia subtilis Kunze

Egg (Pl. I, Fig. 8)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.06–1.64 mm.; average of 30 masses, 1.39 mm.; width, 0.54–0.69 mm.; average of 30 masses, 0.63 mm.

Shape. — Egg with gelatinous envelope elongate; ends of envelope rounded; gelatinous coat thick on sides of egg; upper and lower gelatinous surfaces attached to leaves. Gelatin-covered eggs, in groups, deposited in an irregular mass between two floating leaves.

Color. — Gelatinous envelope translucent; cream to light yellow; light-yellow egg visible within gelatinous border.

Location. — Deposited between two floating leaves. Collected on *Polygonum amphibium*, *Polygonum hydropiperoides*, *Nymphaea advena*, *Sparganium angustifolium*, and *Sparganium diversifolium*; collected on the latter only when leaves are broken so that they float.

Egg

Size. — Length, 0.98–1.17 mm.; average of 30 eggs, 1.05 mm.; width, 0.36–0.43 mm.; average of 30 eggs, 0.41 mm. Length and width increasing with development.

Shape. — Elongate; one end bluntly rounded, other end bluntly pointed; upper side of egg convex, under side straight; chorion thin, apparently smooth; micropyle not visible.

Color. — Light yellow throughout development; yolk colored more in middle of egg than at ends; two rows of black ocelli appearing before hatching, three in front row and two in back.

Period of development. — Sixteen days.

LARVAE

General features (Pl. II, Fig. 20)

Eruciform; 12–16 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly from middle of body,

fifth and sixth abdominal segments usually as large as fourth, diameter of seventh smaller; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad. Legs of moderate size. Posterior segments often a distinct gray.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 31)

Flat, triangular, about as long as width of base. Two apical teeth, outer tooth bluntly pointed and moderately curved, inner tooth curving strongly toward cutting edge. Lateral surface curved, upper half convex and continuous with outer tooth, remaining surface to condyle varying between convex and concave; beak portion serving as extensor muscle attachment, curving laterad and caudad, usually with a middle indentation. Cutting edge curved, region just proximad of inner tooth a long moderate concavity with numerous pointed denticles, region proximad of serrate concavity straight to convex but usually convex in basal third. Border of basal end between condyle and cutting surface curved, median portion convex with median and lateral concavities.

Frons (Pl. IV, Fig. 54)

Pentagonal; distance between lateral angles usually distinctly longer than distance between occipital angle and mid-anterior point; posterolateral edge distinctly shorter than distance between lateral angles and usually slightly convex to occipital region; occipital region pointed or round, when pointed short and moderately narrowed; anterior angles closer to 120° than 100° ; heavily sclerotized anterolateral band generally bending strongly laterad, usually weakly curved. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 65)

Five-sided; from one and one-half to two times as wide as long; posterolateral wings projecting only slightly laterad or continuous with lateral border; remaining part of lateral sides straight-oblique or curved; mid-posterior projection short; anterior margin emarginate, with moderate to deep concavity limited to region between second marginal setae, lateral concavities in region of angular setae. Eight marginal setae; angular longest; second generally slightly

longer than third; fourth sometimes as long as third; second closer to third than to angular; distance between setae of fourth pair greater than that between third and fourth pairs; distance between second and third greater than that between third and fourth. Six discal setae; proximal longest; median setae lateral and usually slightly posterior to distal; distal setae capable of extending from beyond anterior margin to tips of third marginal setae. Two lateral setae, lateral and usually slightly anterior to proximal. Four pitlike structures; one pair posterior and usually slightly lateral to distal setae; the other pair generally directly lateral to proximal setae. All setae thin and tapering to a fine point. Heavily sclerotized band extending from insertion of third and fourth marginal setae to point near bases of proximal setae.

Lacinia (Pl. VI, Fig. 76)

Short; needle-shaped portion one fourth to one third shorter than bow-shaped portion and approximately as long as region bearing hairlike projections; chitinous process about twice as long as needle-shaped structure.

Chitinous bow of labium (Pl. III, Fig. 43)

Semicircular; posterior part generally thick; without irregularities.

Caudal spine (Pl. VI, Fig. 87)

Short; a line from posteroventral end of basal part to apex of hook slightly longer to one third longer than length of basal part; hook-shaped portion four to six times as long as soft-walled oval space enclosing spiracle. Stout, weakly curved, tapering evenly to point.

Body setae (Pl. IX, Fig. 98)

Anterior tergal setae numerous, four to six rows in first six abdominal segments, two to five rows in mesothorax and metathorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, separate or connected by one row of setae; few setae in seventh, usually less than twenty, often between six and sixteen. Number of posterior tergal setae moderate or large, about two to four rows in central region of mesothorax and metathorax, varying within band from two to five rows in first six abdominal seg-

ments but usually with four or five rows in central region; often continuing cephalad in seventh abdominal; separated or connected by one row with anterior tergal in mesothorax and metathorax. Supraspiracular separated into two groups in mesothorax and metathorax; elongate and not divided in first six abdominal segments; usually not extending caudad to anterior row of posterior tergal band in first five abdominal segments, those of sixth often extending beyond this point; first six abdominal segments generally coalescing with anterior tergal band, seventh separated from anterior tergal band; setae sparse in seventh, usually less than seven, often between one and five; seventh sometimes coalescing with posterior tergal band. Infraspiracular of mesothorax and metathorax usually separated into two groups; generally fewer in seventh segment. Fewer pedal setae in seventh abdominal. Anterior sternal of mesothorax and metathorax composed of one to three continuous rows of setae; distinctly separated from posterior sternal. Posterior sternal of mesothorax and metathorax usually in two groups. Sternal of seventh abdominal in two groups. All body setae generally short and thin.

Donacia aequalis Say

EGG (Pl. I, Figs. 9, 12)

Egg mass

Shape. — Eggs lodged in gelatinous matrix, not in individual envelopes; irregular arrangement between two parts of one *Sagittaria* leaf; parts of leaf adhering to each other by gelatinous substance.

Color. — Gelatinous matrix translucent; white; egg a distinct yellow.

Location. — Deposited between tip of blade of one arrow-shaped leaf and surface of blade, tip turned back and attached to surface of blade by gelatinous substance. Collected on *Sagittaria latifolia*.

Egg

Size. — Length, 0.69–0.76 mm.; average of 30 eggs, 0.73 mm.; width, 0.32–0.40 mm.; average of 30 eggs, 0.35 mm. Length and width increasing with development.

Shape. — Short; both ends usually broadly rounded; one side generally convex, other side usually straight; chorion thin, apparently smooth; micropyle not visible.

Color. — Yellow throughout development; colored yolk concentrated near middle; two rows of brown ocelli appearing before hatching, three in front row and two in back.

Period of development. — Eight days.

LARVAE

General features (Pl. II, Fig. 21)

Eruciform; short, 8–10 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad or cephalad. Legs of moderate size. Usually cream-colored.

Ocelli

Five; two rows, three in front row and two in back; black.

Mandible (Pl. III, Fig. 32)

Flat, triangular, about as long as width of base. Two apical teeth, outer one bluntly pointed, inner one often rounded, both curving strongly toward cutting edge. Lateral surface curved, upper third strongly convex and continuous with outer tooth, remaining surface to base of condyle weakly convex; beak portion serving as extensor muscle attachment, curving laterad and caudad. Cutting edge curved, region just proximad of inner tooth a short concavity with large denticles, concavity as long as outer surface of inner tooth, usually convex in proximal half. Border of basal end between condyle and cutting surface curved, short indentation just lateral to cutting surface, remaining surface evenly convex.

Frons (Pl. IV, Fig. 55)

Pentagonal; distance between lateral angles from slightly longer to distinctly longer than distance between occipital angle and mid-anterior point; posterolateral edge shorter than distance between lateral angles and usually approximately straight except for a shallow concavity posterior to lateral angle and a slight concavity in occipital region; occipital point not greatly narrowed and not elongated; anterior angles varying in width, tip of angle often evenly rounded; heavily sclerotized anterolateral band projecting strongly and conspicuously laterad, strong curve often occurring only near lateral angle. Eight long setae. Two pitlike structures.

Labrum (Pl. V, Fig. 66)

Five-sided; from one and one-half to two times as wide as long; posterolateral wings projecting only slightly laterad or continuous with lateral border; remaining portion of lateral surface varying from evenly curved to straight-oblique; anterior margin emarginate, with a long median concavity and two small lateral indentations confined to region of angular setae, the two lateral indentations appearing as part of lateral rather than anterior border. Eight marginal setae; angular usually slightly longer; inner setae usually equal, second marginal sometimes slightly longer; second, third, and fourth approximately equidistant, distance between second and third sometimes slightly greater than that between third and fourth; second closer to third than to angular; distance between setae of fourth pair usually slightly greater than that between third and fourth pairs. Six discal setae; proximal longest; median setae lateral and generally slightly posterior to distal; distal setae usually capable of extending to anterior margin, generally projecting up-right. Two lateral setae, lateral and in line with or slightly anterior to proximal. Four pitlike structures; one pair posterior and very often slightly lateral to distal setae; the other pair varying from posterior to lateral to proximal setae. All setae tapering to a fine point. Heavily sclerotized band extending from mid-posterior point to all marginal setae.

Lacinia (Pl. VI, Fig. 77)

Short; needle-shaped portion approximating length of bow-shaped portion, and longer than region bearing hairlike projections; chitinous process about one third longer than bow-shaped and needle-shaped portions.

Chitinous bow of labium (Pl. III, Fig. 44)

V-shaped; posterior point a solid piece.

Caudal spine (Pl. VI, Fig. 88)

Short; a line from posteroventral end of basal part to apex of hook about as long as length of basal part; hook-shaped portion about four to five times as long as soft-walled oval space enclosing spiracle. Posterior surface strongly convex, tapering evenly to blunt point.

Body setae (Pl. IX, Fig. 99)

Anterior tergal setae few, two to four rows in first six abdominal segments, one to two rows in mesothorax and metathorax; three groups in mesothorax, metathorax, and first six abdominal segments, usually separated in mesothorax and metathorax and separate or connected by a single row in first six abdominal segments; a definite band of one to three rows of setae in seventh abdominal, usually more than twenty setae, often between twenty-two and thirty. Posterior tergal setae few, one or two rows of closely placed setae in a definite band in mesothorax, metathorax, and first four abdominal segments, one, two, or more rows in fifth and sixth abdominal; seventh having a definite band with an increased number of setae in central region; usually not connected with anterior tergal in mesothorax and metathorax. Supraspiracular separated into two groups in mesothorax and metathorax; usually separated into two groups in first six abdominal segments, sometimes two groups connected by one row; usually not extending caudad to anterior row of posterior tergal band in first six abdominal segments, sometimes extending caudad to anterior row in sixth abdominal; coalescing with anterior tergal band in first six abdominal segments, usually separated from anterior tergal in seventh but sometimes connected; setae sparse in seventh, usually less than ten; usually in two groups in seventh, posterior group coalescing with posterior tergal band. Infra-spiracular separated into two groups in mesothorax and metathorax; often slightly fewer in seventh abdominal. Pedal setae often coalescing with some abdominal sternal groups; often fewer in seventh. Anterior sternal not numerous in mesothorax and metathorax, two or three rows in central region, sometimes a few setae caudad to third row; not coalesced with posterior sternal groups. Posterior sternal in two separated groups in mesothorax and metathorax, sometimes fused by one or two rows in middle. Sternal of seventh abdominal separated into two groups; those of sixth separated into two groups or continuous. Setae moderate to stout, length moderate in all segments.

Donacia pubicollis Suffrian

EGG (Pl. I, Fig. 5)

Egg mass

Size. — Length of egg and gelatinous envelope, 1.46–1.83 mm.; average of 30 masses, 1.67 mm.; width, 0.58–0.76 mm.; average of 30 masses, 0.68 mm.

Shape. — Egg with gelatinous envelope elongate; envelope often extended at one end as pointed gelatinous tail; gelatinous coat thick over top and sides of egg. Gelatin-covered eggs, in groups, arranged in single row on inner sides of submerged culm leaves or on culms covered by leaves; long axes of envelopes parallel with or oblique to edge of leaf; envelopes separated or with ends in contact.

Color. — Gelatinous envelopes translucent; white; coat over top of egg usually thick enough to give white appearance to whole mass when viewed with naked eye.

Location. — Deposited on inner sides of submerged leaves or on culms underneath submerged leaves of *Phragmites communis*.

Egg

Size. — Length, 1.13–1.31 mm.; average of 30 eggs, 1.28 mm.; width, 0.47–0.54 mm.; average of 30 eggs, 0.51 mm. No apparent change in size during development.

Shape. — Elongate; one end bluntly rounded, other end bluntly pointed; chorion thin, apparently smooth; micropyle not visible.

Color. — Cream throughout development; colored yolk concentrated near middle; usually two rows of black ocelli appearing before hatching, three in front row and two in back, number and arrangement sometimes varying in this species.

Period of development. — From 12 to 13 days.

LARVAE

General features (Pl. II, Fig. 22)

Eruciform; large, 13–16 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly from middle of body; seventh abdominal segment not greatly reduced; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad. Legs of moderate size. Varying from cream-colored to white.

Ocelli

Generally five; two rows, usually three in front row and two in back, number and arrangement sometimes varying in this species; black.

Mandible (Pl. III, Fig. 33)

Flat, triangular, about as long as width of base. Two apical teeth, rounded, curving weakly toward cutting edge, inner tooth sometimes nearly absent. Lateral surface curved, upper half convex

and continuous with outer tooth, remaining part to condyle varying with convex and concave portions; beak portion serving as extensor muscle attachment, curving laterad and caudad, usually with a middle indentation. Cutting edge curved, distal half a shallow depression with an irregular surface, proximal half usually convex. Border of basal end between condyle and cutting surface uneven, often with median convex portion and lateral and median concavities.

Frons (Pl. IV, Fig. 56)

Pentagonal; distance between lateral angles usually approximating distance between occipital angle and mid-anterior point, sometimes distinctly longer; posterolateral edge generally distinctly shorter than distance between lateral angles and usually concave in caudal one third to one half; occipital region pointed, not greatly narrowed; anterior angle generally closer to 100° than to 120° , tip of angle pointed or round; heavily sclerotized anterolateral band curving weakly to moderately laterad. Eight long stout setae. Two pitlike structures.

Labrum (Pl. V, Fig. 67)

Five-sided; from less than one and one-half to slightly more than one and one-half times as wide as long; posterolateral wings projecting laterad and continuing down to bases of medial setae; remaining part of lateral sides curving to unite with anterior margin just lateral to angular setae; anterior margin curved or straight. Eight marginal setae; angular longest; second usually slightly longer than third, sometimes only thicker; fourth generally as long as third, sometimes slightly smaller; second closer to third than to angular; distance between second and third usually greater than that between third and fourth; distance between setae of fourth pair generally not greater than that between third and fourth pairs. Six discal setae; proximal longest; median lateral and varying from anterior to posterior to distal; distal capable of extending to and often beyond apices of third and fourth marginal setae. Two lateral setae, lateral and generally anterior to proximal. Four pitlike structures; one pair posterior to distal; the other pair lateral and generally slightly posterior to proximal. All setae very stout and tapering evenly to a point; second, third, and fourth marginal sometimes blunt but still tapering evenly. Heavily sclerotized band usually extending from

mid-posterior edge to insertion of fourth marginal setae, sometimes not connected with mid-posterior edge.

Lacinia (Pl. VI, Fig. 78)

Short; needle-shaped portion usually about one third shorter than bow-shaped portion and slightly shorter to about one fifth shorter than region bearing hairlike projections; chitinous process from two to three times as long as needle-shaped structure.

Chitinous bow of labium (Pl. III, Fig. 45)

Semicircular; posterior portion slightly thicker; a posterior point sometimes present.

Caudal spine (Pl. VI, Fig. 89)

Short; a line from posteroventral end of basal part to apex of hook slightly longer to one fourth longer than length of basal part; hook-shaped portion four to five times as long as soft-walled oval space enclosing spiracle. Stout; posterior edge strongly convex; tapering evenly to stout point.

Body setae (Pl. X, Fig. 100)

Anterior tergal setae moderate in number, about four to five rows of widely separated setae in central region of metathorax and first six abdominal segments, about three to four rows in mesothorax; three definite groups in mesothorax, metathorax, and first seven abdominal segments, central groups separate or connected with lateral groups by one row of setae in first seven abdominal segments; seventh composed of more than twenty-five setae. Posterior tergal setae moderate in number, two definite rows forming a distinct straight band in mesothorax, metathorax, and first six abdominal segments, with a few scattered setae out of band, sometimes increased number in sixth; varying from separate to connected by more than one row with anterior tergal group in mesothorax and metathorax. Supraspiracular divided in mesothorax and metathorax; usually continuous in first six abdominal segments but sometimes divided into two groups; generally extending caudad to anterior row of posterior tergal band in first six abdominal segments, sometimes extending to posterior row in fifth and sixth abdominal segments; separated or coalesced with anterior tergal band in first six abdominal segments, separated in seventh; those of seventh elongated, usually ten or more, coalesced with posterior tergal band. Infraspicular separated into

two groups or united in mesothorax and metathorax; number generally not greatly reduced in any abdominal segments. Number of pedal setae not greatly reduced in any abdominal segments. Anterior sternal setae numerous, about four to six rows in mesothorax, about five to seven in central region of metathorax; not coalesced with posterior sternal in mesothorax, wide region in central part of band projecting caudad as a point; coalesced with posterior sternal in metathorax or projecting caudad in central region of band as a point in close proximity to posterior sternal group. Posterior sternal of mesothorax and metathorax in two groups but united at anterior ends. Seventh abdominal sternal separated into two groups or weakly continuous. Body setae long and stout.

Donacia flavipes Kirby

EGG (Pl. I, Fig. 11)

Egg

Size. — Length, 0.84–0.98 mm.; average of 30 eggs, 0.91 mm.; width, 0.43–0.47 mm.; average of 30 eggs, 0.45 mm. No apparent change in size during development.

Shape. — Oval; chorion very thin, easily broken, apparently smooth; micropyle not visible; no gelatinous covering.

Color. — Yolk white. Larva in egg, white; head and dorsal part of thoracic segments brown; two brown caudal spines; usually two rows of five black ocelli, three in front row and two in back, number sometimes varying because of fusion of ocelli.

Location. — Deposited singly in air spaces of *Scirpus americanus* and *Typha latifolia*, in portion of plant projecting out of water; ovipositor puncture in plant parallel with edge of culm or leaf.

LARVAE

General features (Pl. II, Fig. 23)

Eruciform; 10–13 mm. long at time of formation of cocoon; gradually decreasing in diameter anteriorly and posteriorly from middle of body; abdominal segments 8, 9, and 10 short, capable of extending beyond apices of caudal spines; caudal spines projecting ventrad. Legs of moderate size. White.

Ocelli

Five, number sometimes varying because of fusion of ocelli; two rows, three in front row and two in back; black.

Mandible (Pl. III, Figs. 34-35)

Flat, triangular, about as long as width of base. Two apical teeth, outer one round to bluntly pointed and curving weakly toward cutting edge, inner one round or bluntly pointed, usually not extending mediad of the cutting surface. Two setae; one just below mid-point of lateral surface, the other on dorsal surface just distad of neck of condyle. Condyle tilted strongly laterad, unevenly rounded, extremely thick-necked, on basal part of ventral side. Lateral surface approximately straight, curve usually only in region of outer tooth; beak portion serving as extensor muscle attachment, a continuation of remaining part of lateral surface. Cutting edge approximately straight; region just proximad of inner tooth usually with weak denticles, sometimes weakly concave. Border of basal end between condyle and cutting surface straight or curved, when curved having long convex region.

Frons (Pl. IV, Fig. 57)

Pentagonal; distance between lateral angles at least one fifth shorter than that between occipital angle and mid-anterior point; posterolateral edge longer than distance between lateral angles and approximately straight in anterior two thirds, width usually narrowed in posterior third; occipital point sharp and narrowed slightly; anterior angles closer to 120° than to 100° , tip of angle often sharp; heavily sclerotized anterolateral band bending strongly laterad, straight to weakly curved. Four long and six short setae. Two pit-like structures.

Labrum (Pl. V, Fig. 68)

Three-sided; approximately one third wider than long; apparently no separate posterolateral wing; anterior and posterior sides usually continuously curved; anterior margin sometimes somewhat straightened; region between angular setae often equipped with small indentations; heavily sclerotized ventral lateral band continuing beyond lateral setae and following curvature of lateral border. Eight marginal setae; angular longest and projecting medially; second shorter than angular and longer than third, projecting medially; fourth sometimes as long as third; second sometimes equidistant from third and angular; distance between setae of fourth pair greater than that between third and fourth pairs. Six discal setae; proximal longest; median setae lateral and slightly posterior to

distal; distal setae about as long as third marginal and close to third and fourth marginal. Two lateral setae, lateral and in line with or slightly anterior to proximal. Four pitlike structures; one pair posterior and lateral to distal setae; the other pair posterior and lateral to proximal. All setae tapering evenly to a point; distal setae stout. Heavily sclerotized band extending from third and fourth marginal setae to join thicker sclerotized area near proximal setae; all discal setae in thinly sclerotized region.

Lacinia (Pl. VI, Fig. 79)

Short; needle-shaped portion approximately one third as long as bow-shaped portion; chitinous process about four to five times longer than needle-shaped portion. No hairlike projections.

Chitinous bow of labium (Pl. III, Fig. 46)

Semicircular; usually without irregularities.

Caudal spine (Pl. VI, Fig. 90)

Short; a line from posteroventral end of basal part to apex of hook one fifth to one third longer than basal part; hook-shaped portion four to six times as long as soft-walled oval space enclosing spiracle. Weakly curved, tapering evenly to point.

Body setae (Pl. X, Fig. 101)

Anterior tergal setae numerous and not widely separated, four to six rows in first seven abdominal segments, three to six rows in mesothorax and metathorax; three definite groups in mesothorax, metathorax, and first six abdominal segments, central groups connected by one or two rows of setae in mesothorax, metathorax, and first three abdominal segments, sometimes separated in mesothorax and metathorax, connected by one to three rows in abdominal segments 4, 5, and 6; one definite band in seventh segment, well over thirty setae, usually between forty and sixty. Posterior tergal setae numerous and not widely separated, four to six rows in first six abdominal segments with the band often reduced between central area and lateral extremities, three to six rows in mesothorax and metathorax; usually coalescing broadly with anterior tergal band in mesothorax and metathorax. Supraspiracular groups in mesothorax and metathorax separated or coalesced; generally extending caudad to posterior row of posterior tergal band in all abdominal segments, seventh continuous with posterior tergal band, sixth continuous or

weakly separated from posterior tergal band; separated or connected with anterior tergal band in first six abdominal segments, connected in seventh; setae numerous in seventh, more than ten. Infraspicular usually not separated in mesothorax and metathorax; number somewhat reduced in seventh segment. Generally fewer pedal setae in seventh; occasionally coalescing with some abdominal sternal setae. Anterior sternal of mesothorax and metathorax a continuous row; definitely coalesced to posterior sternal in metathorax, coalesced or separated in mesothorax. Posterior sternal divided but connected at anterior ends in mesothorax and metathorax. Sternal of seventh abdominal usually a continuous band, sometimes weakly divided. All body setae short and stout.

KEY TO EGGS OF THE DONACIINI STUDIED

- 1 (6) Egg mass covered by plant tissue only on attached side; mass always submerged; on water lilies 2
- 2 (5) Egg mass arranged in circle or part of circle around hole on under surface of leaf of *Nymphaea advena* or *Castalia odorata*; white; opaque or translucent 3
- 3 (4) Gelatinous matrix opaque; exposed surface flat; on *Nymphaea advena* only *Donacia proxima* Kirby, p. 257
- 4 (3) Gelatinous matrix translucent; exposed surface convex; on *Castalia odorata* only *Donacia cincticornis* Newman, p. 260
- 5 (2) Egg mass irregular; on submerged part of peduncle of *Nymphaea advena* only; yellow; opaque *Donacia piscatrix* Lacordaire, p. 253
- 6 (1) Egg mass completely covered by plant tissue; either submerged, or on or in plant above water; when present on water lily, deposited between two floating leaves; on various aquatic plants 7
- 7 (10) Egg mass deposited on or in emergent aquatic plants, above water surface 8
- 8 (9) Eggs deposited singly in tissues of *Scirpus americanus* and *Typha latifolia*; yolk white; no gelatinous covering
Donacia flavipes Kirby, p. 284
- 9 (8) Eggs deposited between two parts of *Sagittaria latifolia* leaf, glued together by gelatinous matrix; yolk yellow
Donacia aequalis Say, p. 277
- 10 (7) Egg mass deposited on submerged parts of emergent plants or between leaves of floating aquatic plants 11
- 11 (12) Eggs deposited between two floating leaves held together by gelatinous mass; on numerous aquatic plants, such as *Polygonum amphibium*, *Polygonum hydropiperoides*, *Sparganium angustifolium*, *Sparganium diversifolium*, and *Nymphaea advena*
Donacia subtilis Kunze, p. 274

- 12 (11) Eggs deposited on submerged parts of aquatic plants, not between floating leaves 13
- 13 (14) Gelatinous envelopes covering eggs yellow; on inner sides of submerged stipules of *Potamogeton natans*
Haemonia nigricornis Kirby, p. 250
- 14 (13) Gelatinous envelopes covering eggs white; on submerged parts of various plants 15
- 15 (20) Eggs laid in single row between sheath and stem of *Scirpus* or *Phragmites* 16
- 16 (17) Egg mass on *Phragmites communis* *Donacia pubicollis* Suffrian, p. 280
- 17 (16) Egg mass on *Scirpus occidentalis* 18
- 18 (19) Four ocelli showing through chorion before hatching; width of egg mass, 0.43–0.58 mm. *Donacia pubescens* Le Conte, p. 267
- 19 (18) Five ocelli showing through chorion before hatching; width of egg mass, 0.58–0.73 mm. *Donacia quadricollis* Say, p. 270
- 20 (15) Eggs laid in irregular mass between submerged parts of aquatic plants, but not on *Scirpus* or *Phragmites*; collected between stipules and stem of *Potamogeton natans* and between two submerged leaves of *Sparganium angustifolium*
Donacia hirticollis Kirby, p. 263

KEY TO LARVAE OF DONACINI STUDIED

- 1 (6) Hook-shaped portion of caudal spine nine or more times as long as soft-walled oval space enclosing spiracle; on water lilies 2
- 2 (3) Hook-shaped portion of caudal spine serrate at tip; on *Nymphaea advena* only *Donacia proxima* Kirby, p. 257
- 3 (2) Hook-shaped portion of caudal spine not serrate at tip; on *Nymphaea advena* and *Castalia odorata* 4
- 4 (5) Anterior tergal setae of seventh abdominal segment sparse, fewer than twenty; distance between occipital region and mid-anterior point of frons as long as distance between lateral angles; occipital region of frons long and narrow; caudal spine strongly curved; on *Nymphaea advena* only
Donacia piscatrix Lacordaire, p. 253
- 5 (4) Anterior tergal setae of seventh abdominal segment numerous, more than twenty; distance between lateral angles of frons distinctly longer than distance between occipital region and mid-anterior point; occipital region not long and narrow; caudal spine moderately curved; on *Castalia odorata* only
Donacia cincticornis Newman, p. 260
- 6 (1) Hook-shaped portion of caudal spine less than eight times as long as soft-walled oval space enclosing the spiracle; on various aquatic plants other than water lilies 7
- 7 (8) Distance between occipital region and mid-anterior point of frons at least one fifth greater than distance between lateral

- angles; labrum three-sided; needle-shaped portion of lacinia about one third as long as bow-shaped portion; no hairlike projections on lacinia; on *Scirpus americanus*, *Eleocharis palustris* var. *major*, and *Typha latifolia* *Donacia flavipes* Kirby, p. 284
- 8 (7) Distance between occipital region and mid-anterior point of frons not at least one fifth greater than distance between lateral angles; labrum five-sided; needle-shaped portion of lacinia at least one half as long as bow-shaped portion; hairlike projections on lacinia 9
- 9 (10) Tergum of seventh abdominal segment broadly pointed posteriorly and composed of dorsal and ventral portions; green; on *Potamogeton natans* *Haemonia nigricornis* Kirby, p. 250
- 10 (9) Tergum of seventh abdominal segment smoothly rounded laterally and not composed of dorsal and ventral portions; cream or white 11
- 11 (14) Anterior sternal setae of metathorax coalescing with posterior sternal setae or composed of five or more rows of setae in mid-ventral line which converge caudad to form a point; on *Phragmites* and *Scirpus* 12
- 12 (13) Supraspiracular setae of seventh abdominal segments coalesced with anterior tergal setae; outer apical tooth of mandible pointed; larva 9–11 mm. long at time of formation of cocoon; on *Scirpus occidentalis* *Donacia pubescens* Le Conte, p. 267
- 13 (12) Supraspiracular setae of seventh abdominal segments not coalesced with anterior tergal setae; outer apical tooth of mandible round; larva 13–16 mm. long at time of formation of cocoon; on *Phragmites communis* *Donacia pubicollis* Suffrian, p. 280
- 14 (11) Anterior sternal setae of metathorax not coalescing with posterior sternal setae; usually composed of one to three rows in metathorax, rarely four complete rows in central region, the latter not converging caudad to form a point 15
- 15 (16) Supraspiracular setae extending caudad to posterior row of posterior tergal band of setae in first six abdominal segments; anterior and posterior tergal setae usually broadly coalesced in mesothorax and metathorax; on *Sagittaria latifolia*, *Sparganium diversifolium*, *Glyceria borealis*, *Sparganium angustifolium*, and *Potamogeton natans* *Donacia hirticollis* Kirby, p. 263
- 16 (15) Supraspiracular setae not extending caudad to posterior row of posterior tergal band of setae in first six abdominal segments; anterior and posterior tergal setae usually not coalesced in mesothorax and metathorax, sometimes connected by one row 17
- 17 (18) Second, third, and fourth marginal setae approximately equally distributed along entire anterior edge of labrum; needle-shaped portion of lacinia approximating length of bow-shaped portion; chitinous bow of labium definitely V-shaped; supraspiracular setae usually separated into two groups in first six abdominal segments; on *Sagittaria latifolia* and *Sagittaria arifolia*
Donacia aequalis Say, p. 277

- 18 (17) Second, third, and fourth marginal setae grouped near middle of labrum; needle-shaped portion of lacinia one fifth to one third shorter than bow-shaped portion; chitinous bow of labium not strongly V-shaped; supraspiracular setae of first four abdominal segments usually not separated into two groups; on *Scirpus*, *Sparganium*, *Typha*, *Sagittaria*, and *Pontederia* 19
- 19 (20) Mid-posterior projection of labrum long and prominent; setae on labrum stout; second, third, and fourth marginal setae of labrum equal in size and usually equidistant; proximal pitlike structure of labrum caudad of proximal seta; mandible with serrate ridge, inner apical tooth often short and round; seventh abdominal segment often with more than twenty anterior tergal setae; on *Scirpus occidentalis* *Donacia quadricollis* Say, p. 270
- 20 (19) Mid-posterior projection of labrum short; setae on labrum thin; second marginal setae of labrum usually slightly longer than third, distance between second and third setae greater than that between third and fourth; proximal pitlike structure generally located lateral to proximal seta; mandible with definite denticles, inner tooth well developed; seventh abdominal segment often with fewer than twenty anterior tergal setae; on *Sparganium diversifolium*, *Sparganium angustifolium*, *Typha latifolia*, *Sagittaria latifolia*, *Pontederia cordata*, and *Sparganium eurycarpum* *Donacia subtilis* Kunze, p. 274

SUMMARY

(1) Eggs and larvae of eleven species of Donaciini occurring in the region of Douglas Lake, Cheyebogan County, Michigan, are described and figured, six of them for the first time. Five species which had previously been studied by Sanderson (1900) and MacGillivray (1903) are here reconsidered.

(2) Keys for identifying both eggs and larvae of these species are presented.

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LITERATURE CITED

- BÖVING, A. G. 1910. Natural History of the Larvae of Donaciinae. Int. Rev. ges. Hydrobiol. Hydrogr., Biol. Suppl., 1: 1-108. 7 pls., 70 figs.
- MACGILLIVRAY, A. D. 1903. Aquatic Chrysomelidae and a Table of the Families of Coleopterous Larvae. New York State Mus., Bull. 68, Entomol., 18: 288-327. 12 pls.
- SANDERSON, E. D. 1900. The Larvae of *Donacia piscatrix*, Lac., and *crassipes*, Fab. Can. Entomol., 32: 249-263. 29 figs.

PLATES I-X

ABBREVIATIONS USED IN PLATES

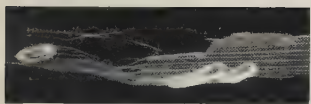
a ¹ -a ⁷	abdominal segments 1-7	ms	medial seta of labrum
alb	anterolateral sclerotized band of frons	mst	mesothorax
as	angular seta of labrum	mt	metathorax
ast	anterior sternal setae of thorax	nc	niche of lacinia
at	anterior tergal setae	ns	needle-shaped portion of lacinia
bs	bow-shaped portion of lacinia	or	occipital region of frons
cp	chitinous process of lacinia	pds	pedal group of setae
ds	distal seta of labrum	pr	posterior tergal setae
hp	hairlike projections on lacinia	ps	proximal seta of labrum
is	infraspicular group of setae	pst	posterior sternal setae of thorax
lg	leg	sp	spiracle
ls	lateral seta of labrum	ss	supraspiracular group of setae
m ² -m ⁴	marginal setae 2-4 of labrum	st	sternal setae

EXPLANATION OF PLATE I

Egg masses

(Enlargements indicated by scales)

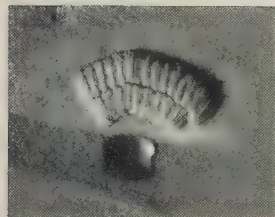
- FIG. 1. *Haemonia nigricornis* Kirby
- FIG. 2. *Donacia piscatrix* Lacordaire
- FIG. 3. *D. proxima* Kirby
- FIG. 4. *D. cincticornis* Newman
- FIG. 5. *D. pubicollis* Suffrian
- FIG. 6. *D. pubescens* Le Conte
- FIG. 7. *D. hirticollis* Kirby
- FIG. 8. *D. subtilis* Kunze
- FIG. 9. *D. aequalis* Say
- FIG. 10. *D. quadricollis* Say
- FIG. 11. *D. flavipes* Kirby
- FIG. 12. *D. aequalis* Say on leaf of *Sagittaria latifolia*



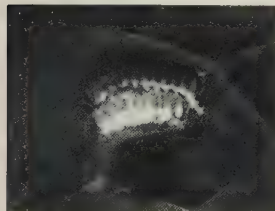
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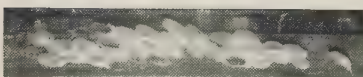


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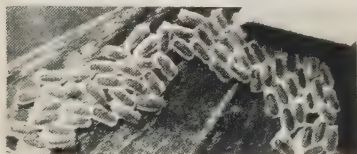
1 cm.



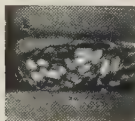
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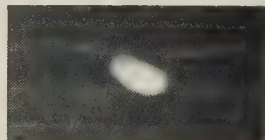
9

1 cm.



10

5 mm.



11

2.5 mm.



12

EXPLANATION OF PLATE II

Larvae

(All photographs on same scale)

- FIG. 13. *Haemonia nigricornis* Kirby
- FIG. 14. *Donacia piscatrix* Lacordaire
- FIG. 15. *D. proxima* Kirby
- FIG. 16. *D. cincticornis* Newman
- FIG. 17. *D. hirticollis* Kirby
- FIG. 18. *D. pubescens* Le Conte
- FIG. 19. *D. quadricollis* Say
- FIG. 20. *D. subtilis* Kunze
- FIG. 21. *D. aequalis* Say
- FIG. 22. *D. pubicollis* Suffrian
- FIG. 23. *D. flavipes* Kirby



13



19



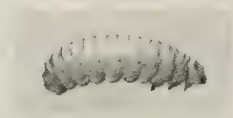
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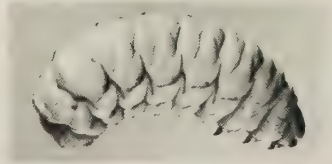
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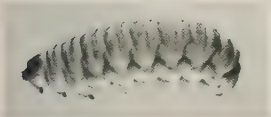
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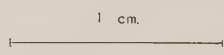
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23



18



EXPLANATION OF PLATE III

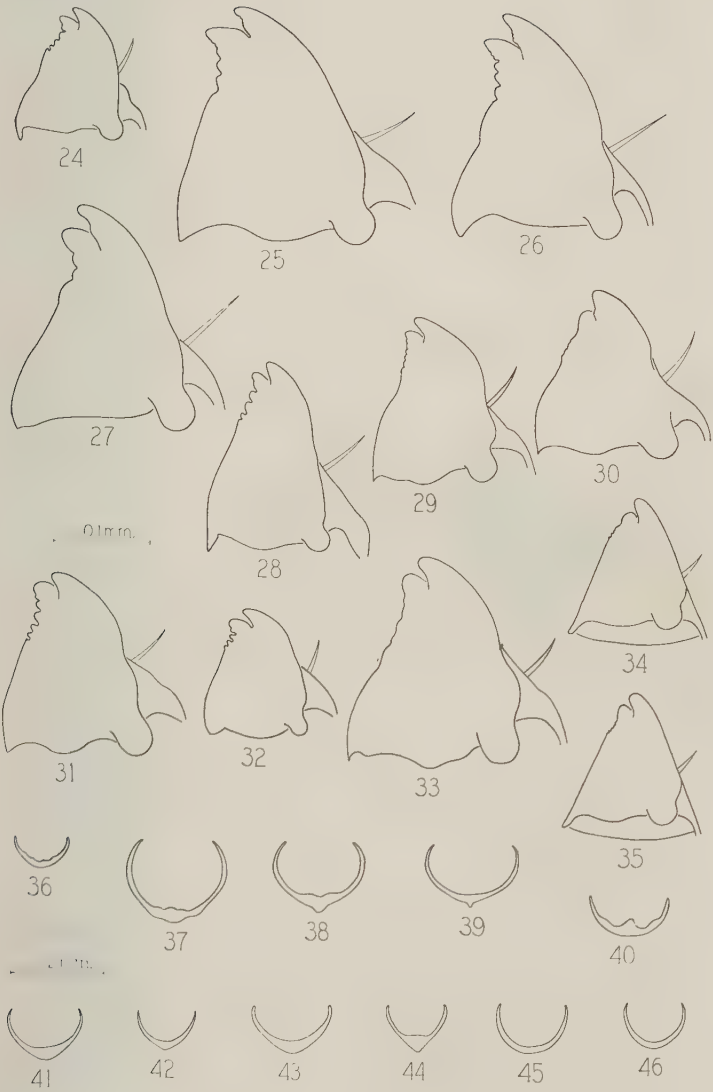
(All drawings on same scale)

Ventral views of mandibles

- FIG. 24. *Haemonia nigricornis* Kirby
- FIG. 25. *Donacia piscatrix* Lacordaire
- FIG. 26. *D. proxima* Kirby
- FIG. 27. *D. cincticornis* Newman
- FIG. 28. *D. hirticollis* Kirby
- FIG. 29. *D. pubescens* Le Conte
- FIG. 30. *D. quadricollis* Say
- FIG. 31. *D. subtilis* Kunze
- FIG. 32. *D. aequalis* Say
- FIG. 33. *D. pubicollis* Suffrian
- FIG. 34. *D. flavipes* Kirby
- FIG. 35. *D. flavipes* Kirby

Chitinous bows of labia

- FIG. 36. *Haemonia nigricornis* Kirby
- FIG. 37. *Donacia piscatrix* Lacordaire
- FIG. 38. *D. proxima* Kirby
- FIG. 39. *D. cincticornis* Newman
- FIG. 40. *D. hirticollis* Kirby
- FIG. 41. *D. pubescens* Le Conte
- FIG. 42. *D. quadricollis* Say
- FIG. 43. *D. subtilis* Kunze
- FIG. 44. *D. aequalis* Say
- FIG. 45. *D. pubicollis* Suffrian
- FIG. 46. *D. flavipes* Kirby

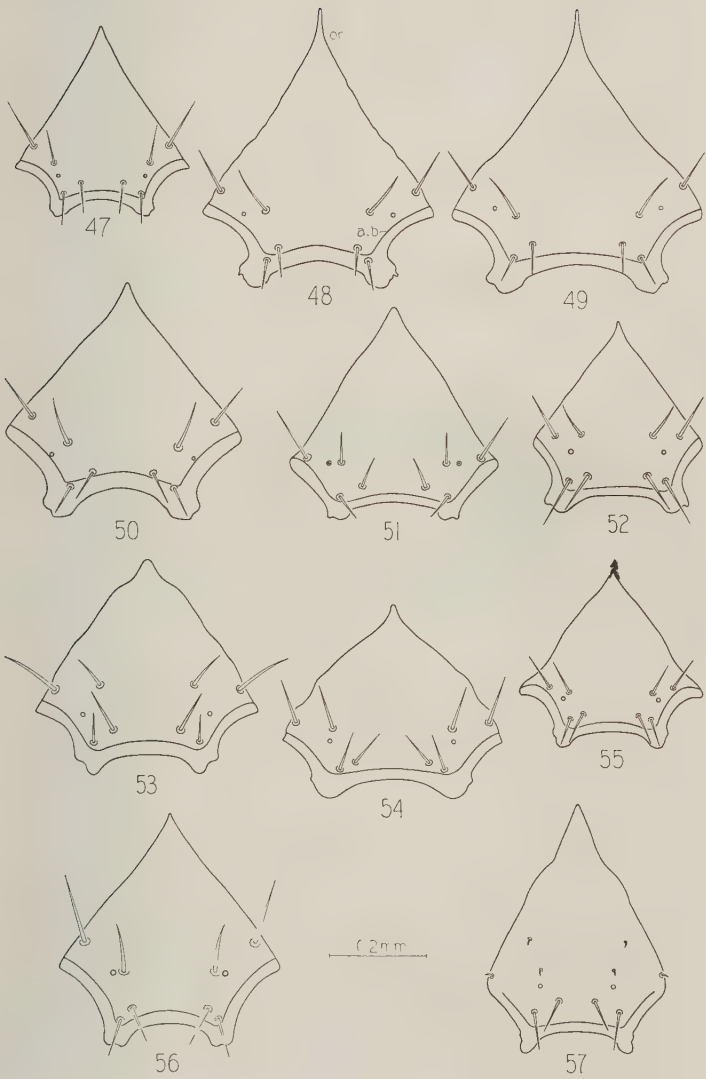


EXPLANATION OF PLATE IV

Dorsal views of frontes

(All drawings on same scale)

- FIG. 47. *Haemonia nigricornis* Kirby
- FIG. 48. *Donacia piscatrix* Lacordaire
- FIG. 49. *D. proxima* Kirby
- FIG. 50. *D. cincticornis* Newman
- FIG. 51. *D. hirticollis* Kirby
- FIG. 52. *D. pubescens* Le Conte
- FIG. 53. *D. quadricollis* Say
- FIG. 54. *D. subtilis* Kunze
- FIG. 55. *D. aequalis* Say
- FIG. 56. *D. pubicollis* Suffrian
- FIG. 57. *D. flavipes* Kirby

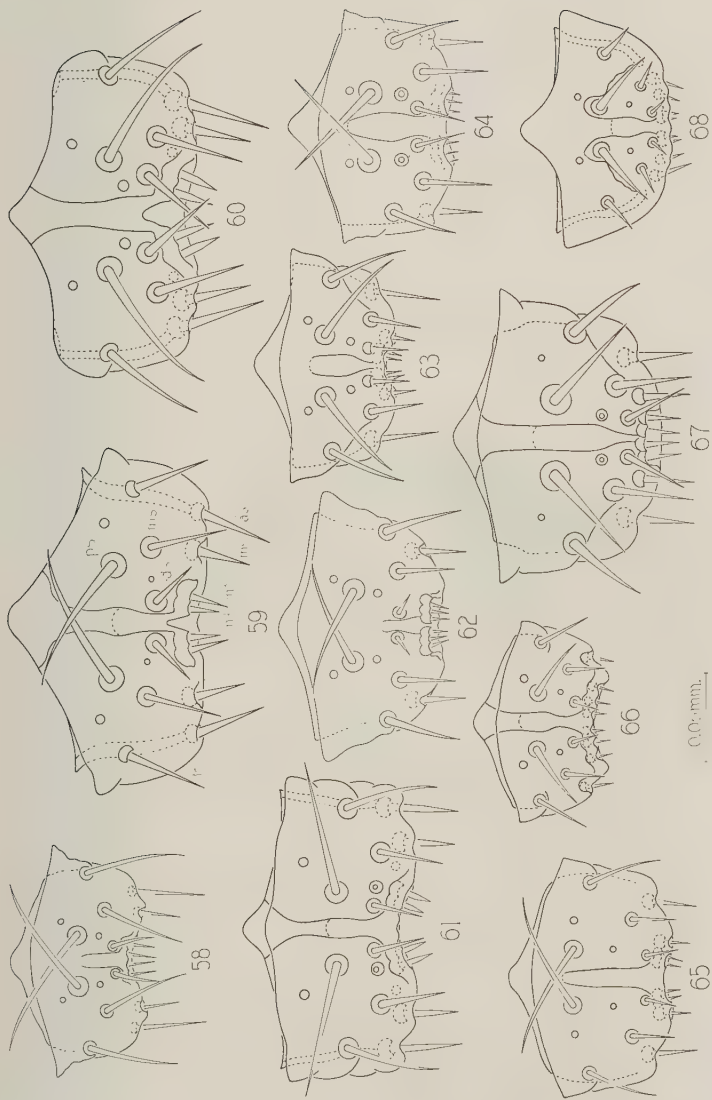


EXPLANATION OF PLATE V

Dorsal views of labra

(All drawings on same scale)

- FIG. 58. *Haemonia nigricornis* Kirby
- FIG. 59. *Donacia piscatrix* Lacordaire
- FIG. 60. *D. proxima* Kirby
- FIG. 61. *D. cincticornis* Newman
- FIG. 62. *D. hirticollis* Kirby
- FIG. 63. *D. pubescens* Le Conte
- FIG. 64. *D. quadricollis* Say
- FIG. 65. *D. subtilis* Kunze
- FIG. 66. *D. aequalis* Say
- FIG. 67. *D. pubicollis* Suffrian
- FIG. 68. *D. flavipes* Kirby



EXPLANATION OF PLATE VI

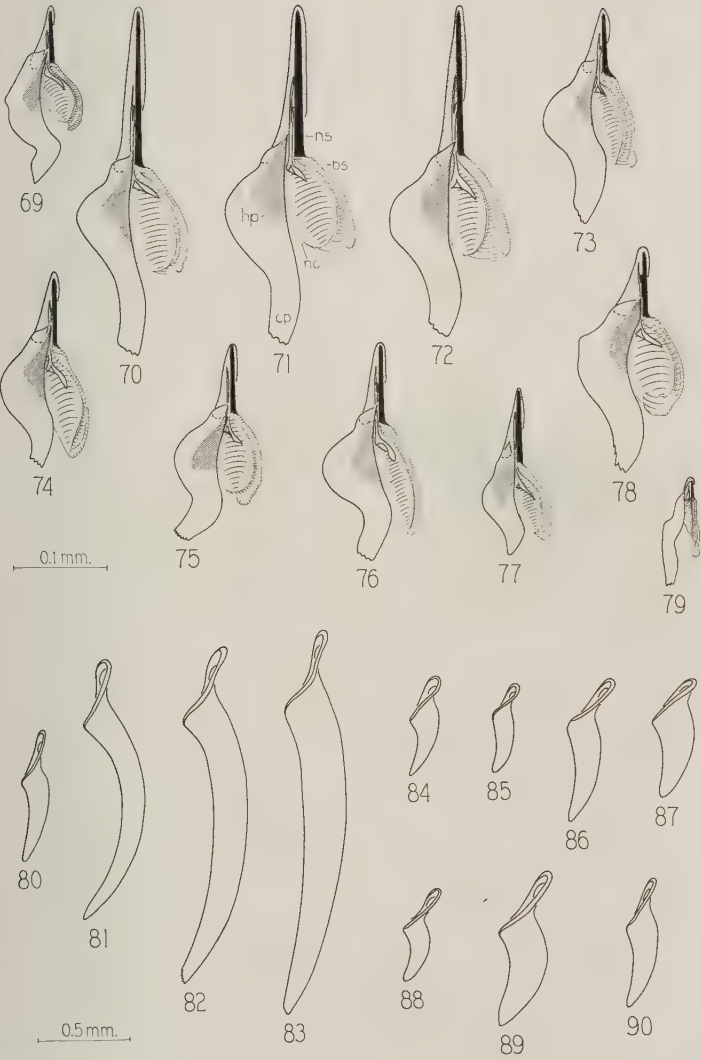
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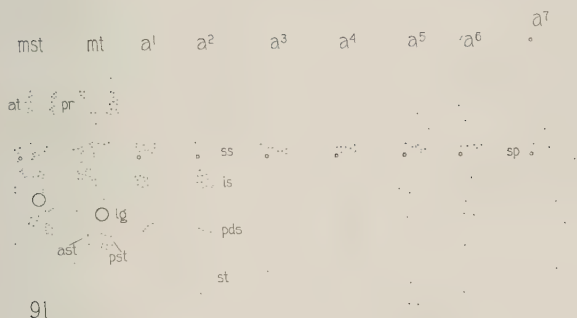
Dorsolateral views of laciniae

- FIG. 69. *Haemonia nigricornis* Kirby
- FIG. 70. *Donacia piscatrix* Lacordaire
- FIG. 71. *D. proxima* Kirby
- FIG. 72. *D. cincticornis* Newman
- FIG. 73. *D. hirticollis* Kirby
- FIG. 74. *D. pubescens* Le Conte
- FIG. 75. *D. quadricollis* Say
- FIG. 76. *D. subtilis* Kunze
- FIG. 77. *D. aequalis* Say
- FIG. 78. *D. pubicollis* Suffrian
- FIG. 79. *D. flavipes* Kirby

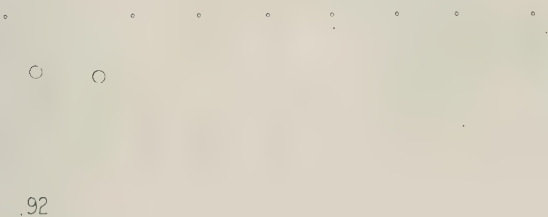
Lateral views of caudal spines

- FIG. 80. *Haemonia nigricornis* Kirby
- FIG. 81. *Donacia piscatrix* Lacordaire
- FIG. 82. *D. proxima* Kirby
- FIG. 83. *D. cincticornis* Newman
- FIG. 84. *D. hirticollis* Kirby
- FIG. 85. *D. pubescens* Le Conte
- FIG. 86. *D. quadricollis* Say
- FIG. 87. *D. subtilis* Kunze
- FIG. 88. *D. aequalis* Say
- FIG. 89. *D. pubicollis* Suffrian
- FIG. 90. *D. flavipes* Kirby

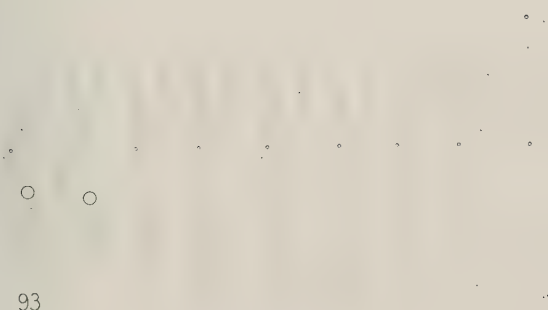




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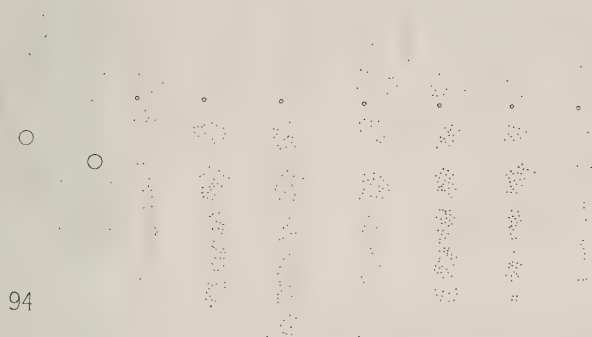
93

Body setae

FIG. 91. *Haemonia nigricornis* Kirby

FIG. 92. *Donacia piscatrix* Lacordaire

FIG. 93. *D. proxima* Kirby



Body setae

FIG. 94. *Donacia cincticornis* Kirby

FIG. 95. *D. hirticollis* Kirby

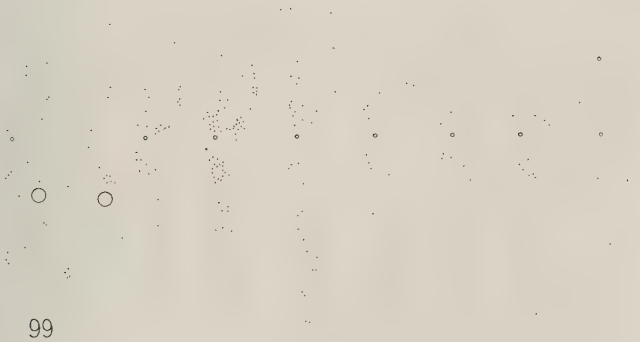
FIG. 96. *D. pubescens* Le Conte



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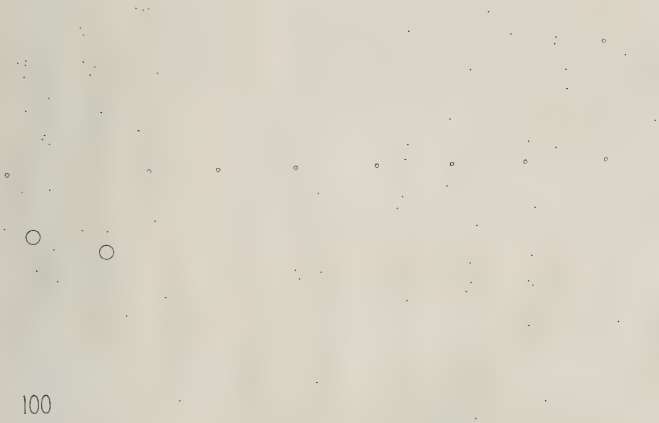
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99

Body setae

- FIG. 97. *Donacia quadricollis* Say
FIG. 98. *D. subtilis* Kunze
FIG. 99. *D. aequalis* Say



100



101

Body setae

FIG. 100. *Donacia pubicollis* Suffrian

FIG. 101. *D. flavipes* Kirby

THE CRANIUM OF A FRESH-WATER SHEEPS-
HEAD FROM POSTGLACIAL MARL IN
CHEBOYGAN COUNTY,
MICHIGAN

CARL L. HUBBS

THERE are fields of research in which even fragments of concrete data are eagerly seized upon. This is especially true of subjects like zoögeography, in which conclusions can ordinarily be drawn only from circumstantial evidence. In recent attempts to trace the postglacial redispersal of fishes in North America (see especially Greene, 1935) the lack of purely objective data on the occurrence of fish species in given regions has been a particular deterrent to the drawing of precise conclusions. It is with much satisfaction, therefore, that I am able to record with certainty the ancient, postglacial, occurrence of the fresh-water sheepshead, *Aplodinotus grunniens* Rafinesque, in the waters of Burt Lake, Michigan, or in one of its postglacial precursors.

While digging a boat well at Burt Lake during the summer of 1937 Mr. J. H. Greenman uncovered a remarkably well preserved cranium of *Aplodinotus* (Pl. I). He specifies that the skull was found thirty feet from the water's edge and exactly six feet below the surface of the level ground (which here lies only a few feet above the lake level). It was under "about two feet of black muck or turf and about four feet of marl, right at the bottom of the marl where the marl bed lay on solid red clay." A coating of white marl remains in some of the cavities of the skull bones. In the unpublished soil survey of Cheboygan County, according to Lee R. Schoenmann (personal communication), the superficial "two feet of black muck or turf," which here overlies the marl, has been identified as a local area of Edwards muck associated with Granby sand.

The location of the discovery is on Greenman Point, near the north end of the east shore of Burt Lake, in Section 14, T. 36 N.,

R. 3 W. (Burt Township), Cheboygan County, Michigan. By straight line the site lies thirteen miles inland from the Straits of Mackinac at Cheboygan. Burt Lake, a large body of water, is one of the main elements of the "Inland Waterway,"¹ which during most of postglacial time constituted a strait connecting Lakes Michigan and Huron (Leverett and Taylor, 1915).

As to the age of this semifossil fish skull, I have consulted a number of scientists who are conversant with the region, including the glacial geologists Frank Leverett and George M. Stanley, the limnologist P. S. Welch, and the land and economic survey expert Lee R. Schoenmann. All agree that the sheephead in question must have lived in postglacial time, certainly many centuries ago. Without a specific field examination, however, no one is ready to correlate definitely the occurrence of the fish with any of the series of postglacial lakes. Dr. Stanley suggests, however, that, because of the frequent finding of such marl and peat deposits of Nipissing age not far above present lake levels and the paucity of such materials in Algonquin deposits, a correlation with Lake Nipissing seems most plausible. The penetration of foramina in the bones by marl-preserved root or stem fibers makes it seem virtually certain that the skull was laid down in shallow water and, therefore, during neither of the high levels of Lake Algonquin.

The occurrence of *Aplodinotus grunniens* in the Inland Waterway during postglacial time takes on added significance in view of the almost certain absence of the species in these waters at the present time. The sheephead is an essentially southern species, as Barney (1926) has pointed out in detail. (I have taken it as far south as the Río de la Pasión, a tributary of the Río Usumacinta in El Petén, Guatemala.) It is rather common in southern Lake Michigan, in Lake Erie, and in Saginaw Bay of Lake Huron, and there is one published record for the mouth of the Au Sable River, which enters Lake Huron north of Saginaw Bay. Records of the commercial fish catch (made available by Dr. Ralph Hile of the United States Bureau of Fisheries) indicate an occasional straggling northward as far as the Beaver Islands in Lake Michigan, along the northern shores of Lake Huron in Michigan, and even into St. Martin Bay on the north

¹ See Chart of Inland Route of Navigation, Michigan, from Cheboygan, to Little Traverse Bay, Including Petoskey and Harbor Springs, 1930 (War Department, Lake Charts, Cat. No. 66).

side of the Straits of Mackinac.² It is not surprising, therefore, to find proof of the penetration of the species into the location of Burt Lake, particularly at a time when the Inland Waterway was a broad, shallow, and probably turbid strait, providing conditions which would be favorable to the species. At present the sheepshead occurs even much farther north, in cool, shallow, and often turbid waters (Barney, 1926; Dymond and Hart, 1927). Its presumed use of the southern outlets of the glacial Great Lakes (Barney, 1926; Greene, 1935) is confirmed.

The postglacial cranium of *Aplodinotus grunniens* (Pl. I), measuring 156 mm. from the tip of the vomer to the end of the supra-occipital crest, represents a rather large specimen of the species as compared with the usual size of present-day adults. The bones of the species found in Indian burials and middens³ prove, however, that vastly larger sizes were attained in prehistoric time.

When this beautifully preserved skull is compared with that of a Recent specimen from Lake Eric, only slight differences are apparent (Pl. I). The greater thickening and the coarser sculpturing of the bones are attributable to the age of the postglacial individual (about twenty years, as determined from the winter lines on the membrane bones). Owing to the marked bilateral asymmetry of the postglacial skull and of the variation shown by Recent skulls, differences in the foramina and in details of sculpturing probably lose all significance.

The discoverer of the postglacial *Aplodinotus* cranium, Mr. J. H. Greenman, has very kindly deposited the specimen in the University of Michigan Museum of Zoology. We are grateful to Dr. Max M. Peet of Ann Arbor, a summer neighbor of Mr. Greenman, for recognizing the scientific value of the specimen and for bringing it to the Museum with information on the remarkable find.

UNIVERSITY OF MICHIGAN

² There is no evidence, however, to confirm the expectation of Barney (1926) that the species will be found to occur in Lake Superior.

³ A study of these remains has been in progress for some time.

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CRANIA OF POSTGLACIAL AND RECENT SHEEPSHEAD

Two crania are shown, each in posterior, dorsal, and lateral aspect. The larger, postglacial, skull is 156 mm. long from tip of vomer to end of supraoccipital crest. The smaller, Recent, cranium, 122 mm. long, was prepared from a Lake Erie specimen. Photographs, to the same scale, by F. W. Ouradnik

NOTES ON THE BIRDS OF ZANKSKAR AND PURIG, WITH APPENDIXES GIVING NEW RECORDS FOR LADAKH, RUPSHU, AND KULU

WALTER KOELZ

ZANKSKAR is one of the loftiest inhabited districts on earth. It is also one of the remotest areas of the Indian Empire. Few ornithologists have ever visited it, and the only records I can find of its birds are of those collected by Dr. Stoliczka and Mr. Osmaston. The former gives 1866 and 1868 as dates of collection of two species of birds at Padum,¹ and A. von Pelzeln² records two species from Parkachen and Rangdum Gompa. Mr. Osmaston's data³ are more numerous.

I passed through the district from Kāngi La to Rangdum and thence across Pensi La to Padum and Shingkun La (often written Shingo), on the main Himalayan Ridge, into Lahul between September 9 and October 1, 1931, and from Shingkun La to Rangdum and then down the Rangdum River through Purig to Kargil from July 11 to 27, 1933. On each occasion the purpose of my visit was other than ornithological, and birds were collected only as opportunity offered. In Purig I spent but three days and had no time to turn from the road. It appears, however, in comparison with the bird population of similar districts, that my collection is probably fairly representative of the species likely to occur, and since even an imperfect record is better than none, I present my notes. They supplement our meager knowledge of the bird life of the high altitudes of the Himalayas, to the furtherance of which there is room for the energies of many workers. Habitats in the mountains are quite

¹ Stoliczka, F., "Ornithological Observations in the Sutlej Valley, N. W. Himalaya," *Journ. Asiatic Soc. Bengal*, 37: 62-63. 1868.

² von Pelzeln, A., "On the Species of Birds Collected by Dr. Stoliczka in Tibet and the Himalayas," *Ibis*, 4: 302-321. 1868.

³ Osmaston, B. B., "A Tour in Further Kashmir," *Journ. Bombay Nat. Hist. Soc.*, 34, No. 1: 108-134. 1930.

varied, and even in a tiny area great labor and much time are required to explore them all. In addition, the avian population of the mountains is of complex constitution; there are birds that remain permanently, some that spend only the summer or the winter, and others that are merely transients, and many of these have altitudinal preferences that may vary with the season. For this reason it may be expected that for many years to come careful observers will be adding names to the faunal lists that we now have.

The Districts of Zankskar and Purig lie against the backbone of the Himalayas, and an irregular flanking range shuts them off from the lofty great "North Plain" of Tibet. The winds from India become drier with each range they cross, so that they provide little precipitation for places beyond. The old glacial plain, especially in Zankskar, is therefore relatively well preserved and, being broad in places, furnishes cultivation sites that could support a much greater human population.

The character of the country varies considerably along the route from Lahul to Ladakh, and there are great changes in altitude. The route can be divided roughly into five stretches, according to the physical characteristics, each of which will be described in the succeeding paragraphs.

The road along the little stream that runs down from Shingkun La (elevation about 16,000 feet) to Padum (about 12,000 feet) is against the rounded worn mountain flanks, and winds up and down and in and out of the gorges of the little streams that drain some snowcap far back in the jumbled hills. The Great Pass was still under deep snow in mid-July, but by the end of the summer all snow and ice had melted except a little glacier that lies in a crevice at the side of the path. Plants grow abundantly below the Pass, where the influence of the reservoir of snow is felt. Thereafter the region is semi-arid and the pink-brown, dove-gray, and purple-black hill slopes are sprinkled with patches of green only near their crests. Along the river there is nothing lush but the fields of the few scattered villages that are passed before the oft-strengthened stream mouths into the Zankskar River at Padum, and the occasional patches of green that mark places where a brook joins the river. At Tetha a few willows are first seen, and in the villages below the junction of the Tsarup poplars put in their appearance. Rosebushes, some of them ten feet high, covered in summer with glorious pink blooms and in fall with

only little less attractive crimson hips, are sometimes common along the road, and there are a few small thickets of willow and tamarisk.

The Zankskar River, which rises in mighty glaciers beside Pensi La, flows down a valley that for the high mountains is broad and open, and the view from Padum toward Pensi La is one of the finest in the province. The plain, at Padum a mile wide, fertile, and well watered, extends up to Abring, a stage below the pass. Occasional spurs are thrust out from the mountain side across the valley, and the river's course alternates between its broad gravelly bed of the plain and the narrow gorges it has cut through the obstructing walls. The mountains are still rounded and worn, with vegetation caps around their peaks. How rich this floral mantle is the ascent of Pensi La, about 16,000 feet high, discloses. At its foot there occur extensive willow thickets around copious streams and springs.

Across the Pass begins the Rangdum River that flows to join the Suru at Kargil. To Rangdum monastery (about 13,000 feet), and for five miles or more below, the valley is broad and bordered with springs that make the floor a water-soaked meadow of green. The valley of the tributary that comes down from Kangi La and Ling-shot and mouths at Rangdum is not marshy but remarkably rich in herbage, and Rangdum is thus the finest pasture ground in the whole district. Thickets of willow are numerous, and in July flowers glorify the whole landscape. A little primrose makes blocks of pink of even half an acre in the pattern of green. Settlements in this section are rare; in addition to the monastery they comprise only three small villages.

From Gyama Tongdze (12,200 feet) the road is up and down over old glacial drift against the now narrowed and rubble-strewn mountain walls. The stream is a torrent in its gorge. The last of the roses straggle along the foot of the mountains and on the patches of soil among and below the rubble hardy flowers make a cheerful showing in July. Traces of former settlements may be seen.

The District of Purig begins to be inhabited at Parkachen (about 11,000 feet), and from there to Sangu, about halfway to Kargil (about 8,900 feet), villages become increasingly common and cultivated patches are almost constantly in view. The river has here turned again to run against the great ridge, with its jagged peaks and sparkling glaciers, and the somber, weary, age-worn countenance of

the landscape changes for a brief space to one of freshness, exhilaration, and all-defying youth.

Beyond Sangu the grandeur of the scenery passes, and the mountain slopes are drier than ever. Villages are less common, but two great oases lie in the course of the valley before it debouches at Kargil (about 8,900 feet). Tsaliko (9,400 feet) is the largest settlement in the district, and Guntung, a few miles below, is one of the thriftiest. After leaving Zankskar one finds the climate progressively milder with decreasing altitude, and the variety of crops increases. In these lower villages even potatoes, corn, and onions are occasionally grown; at Tsaliko there are, besides the now common groves of poplars and willows, a few apple trees; at Guntung mulberries and apricots may be seen.

Zankskar is a high mountain district, with a bird population akin to that of Spiti and high Lahul. Purig is ornithologically like Ladakh, and all its species occur in the Indus valley about Leh.

LIST OF SPECIES

Corvus corax tibetanus Hodgson

In 1933 ravens were observed at Kargiak and at all the towns passed in descending to Padum. A pair was seen at Abring and another at Bok below Pensi La and at Rangdum. The Zankskaris say there is one pair only at every village. In Purig one bird was seen at Parkachen and another at Tangola. A male was taken at Tetha in 1931 and a second at Mune in 1933.

Corvus corone orientalis Eversm.

This species occurs from Tsaliko on down the valley. A specimen was taken at Kargil.

Pica pica bactriana Bp.

Specimens were collected at Tangola on July 26, 1933, and the species was seen at most of the settlements below that place.

Pyrhcorax pyrrhcorax himalayanus (Gould)

These birds are common throughout Zankskar; they do considerable damage to the crops in the fall, when flocks gather in the grain fields. They were seen in Purig at Parkachen and Tangola. Specimens were collected in 1931 at Cha and in 1933 near Seni.

Pyrrhocorax graculus forsythi Stol.

Three birds were seen around Lagong in 1931. No others were observed.

Oriolus oriolus (L.)

An oriole was seen at Guntung, Purig, on July 27, 1933.

Carduelis caniceps caniceps Vigors

In 1931 this bird was common around Hamiling; in 1933, at Mune. Specimens were taken at both places.

Serinus pusillus (Pall.)

This species is rather generally distributed in Zankskar. In 1931 it was found about Tetha and Cha; in 1933, at Kargiak, Cha, and Abring. Specimens were collected at all these places.

Erythrina rhodochlamys grandis (Blyth)

In 1931 this bird was rather common around Cha and Tetha, where roses grew abundantly. In 1933 it was found from Tetha to Burdun.

Erythrina rubicilla eblis Koelz

In 1931 several were seen at Cha; in 1933, only at Lagong and Kargiak. Specimens were collected at all these places.

Erythrina erythrina kubanensis (Laubm.)

This is a generally distributed bird in both districts and is found about all settlements. The Lahul and Ladakh form is certainly not like that of the Eastern Himalayas, which is found in peninsular India in winter, and should not be known as *roseata*.

Pyrrhospiza punicea humii (Sharpe)

The species seems to be very local and has been found in only three places: below Shingkun La near Lagong, at Rangdum, and on Pensi La. Specimens were collected at Lagong and Pensi La in both 1931 and 1933. In 1931 first-plumaged birds were taken on Pensi La on September 12. Males with swollen gonads were taken in female plumage in July.

Leucosticte nemoricola altaica (Eversm.)

In 1931 it was generally distributed in Zankskar in September. In July of 1933 it was found from Lagong to Pensi La, but only singly or in family parties.

Leucosticte brandti haematopygia (Gould)

Specimens of this were taken at Lagong, but it was not observed elsewhere.

Montifringilla adamsi adamsi (Adams)

A bird of high altitudes which is rather common around Lagong. On July 14, 1933, birds in first plumage were flying.

Passer domesticus parkini (Whistler)

Generally distributed; occurs around all villages.

Emberiza cia stracheyi (Moore)

Specimens were taken in 1933 at Tetha, Cha, Munc, and Tangola. It seems to be rare in both districts.

Emberiza icterica (Eversm.)

Only one was seen, a juvenile female taken at Cha on September 24, 1931.

Emberiza buchanani (Blyth)

A male was taken from three seen at Padum on September 17, 1931.

Calandrella acutirostris acutirostris (Hume)

This is a generally distributed bird in Zankskar, but I have no records for Purig. In July, 1933, the birds were breeding and occurred only singly or in twos and threes; in September there were small flocks of from ten to fifteen.

Calandrella brachydactyla dukhunensis (Sykes)

In 1931 from Hamiling to Lagong flocks of fifty to several hundred were regularly seen. Especially large flocks were found at Trangse. This bird seems to be a regular fall migrant through the district; large flocks were found in Spiti in September, 1933.

Alauda arvensis thamarum (Mein.)

Generally distributed around cultivated places from Kargiak through both provinces; abundant at Padum. First-plumaged young were taken at Sangu. In 1931 skylarks were found from Abring to Cha, but since specimens are not available for comparison, I am not sure of their subspecific identification.

Eremophila alpestris longirostris (Moore)

In summer larks were found generally throughout Zankskar and in Purig down to Tangola. On July 10 and 11, 1933, birds in first plumage were taken at Lagong below Shingkun La. In the fall they were rarer, and only occasional specimens were observed, except around Lagong.

The distribution of the races *longirostris* and *elwesi* has often been discussed by ornithologists, and to the diversity of opinion I add mine, recognizing that it is not entitled to rank with those of Hellmayr, Meinertzhagen, Whistler, and others who have concerned themselves with the subject.

Throughout Spiti, Lahul, and Zankskar I have found only one form, *longirostris*. Beyond trans-Himalayan Lahul this form apparently extends to La Chhulung, where I collected five typical specimens from a large flock on August 22, 1933. There were no larks beyond that pass till one reached the More Plain, about ten miles below, and though no obvious barriers exist the very distinct *elwesi* occurs abundantly at the latter locality. In Ladakh I have found few larks. Above Tog on August 19, 1931, I took an adult female of *longirostris*. Across the Indus Valley, near Tsultak, on August 1, 1931, I took a first-plumaged male of that race. Beyond, along Pangong Tso, only *elwesi* occurs. Birds of Debring, Tso Kar, Tso Morari, and Tsaka are of this form. To judge from my observations, then, the dividing line of the two races runs from somewhere between Spiti and Rupshu, across La Chhulung to somewhere west of Taklang La, above Debring, to near Tsultak across Chang La. I have before me 36 specimens of *longirostris* taken in Lahul, Spiti, and Zankskar in 1933, and in previous years I have taken as many more from Lahul and Zankskar. The type locality is Kulu, but larks probably occur there only on the Spiti and Lahul border. Wings of 19 adult males, with the primary tips more or less frayed, measure 124 to 129 mm., of 11 adult females, 112 to 120 mm. Of

elwesi I have 22 from Rupshu and Ladakh and have taken as many more in other years. Wing measurements of 5 adult males, 115 to 122 mm.; of 7 adult females, 110 to 113 mm. In addition to a shorter wing, *elwesi* has a much shorter bill and pinker back. The first plumages are also different in the two forms.

Meinertzhagen (*Ibis*, Ser. 12, 3 : 400. 1927) lists under *longirostris* a number of specimens from near Tsultak that appear from the measurements to include representatives of both races, and it may be that there is a contact zone about Chang La. His Pangong and Tso Kar birds agree in measurements with mine. Meinertzhagen knew typical *elwesi*, and if he considered none of his Ladakh birds of that race, the specimens I call *elwesi* may be of an undescribed form.

Anthus trivialis haringtoni (Witherby)

This species was rather common at Cha in the grain fields between September 20 and 25, 1931, and several specimens were collected. It was also found sparingly on Pensi La on September 13, at Abring on September 15, and at Hamiling the next day.

Motacilla flava beema (Sykes)

A specimen was taken at Rangdum on September 12 and one at Phe on September 16, 1931.

Motacilla citreola calcarata (Hodgson)

Generally distributed throughout Zankskar and most of Purig, where water occurs. A breeding female from Karsha has no yellow or black. Fully fledged young were found at Yuljuk on July 26, 1933.

Motacilla alba alboides (Hodgson)

Generally distributed like the last species. First-plumaged birds occurred at Seni on July 19, 1933. At Yuljuk on July 26 a female with a gray back was collected; it was mated to a typical black-backed male. Furthermore, it has a bill as small as in *personata* specimens. A similar bird with a longer bill was taken at Spitug, Ladakh, on August 7. Meinertzhagen is undoubtedly right when he says (*op. cit.*, p. 406) that females of *alboides* cannot be separated from *personata* females on color alone. Though *alboides* is undoubtedly the breeding bird of Spiti, as it certainly is of Lahul, in September, 1933, I found only *personata* till I was halfway through the province.

Tichodroma muraria L.

In 1931 specimens were taken at Reru and Cha. Two birds were seen at Tetha, two at Cha, and one at Abring in 1933.

Phylloscopus affinis (Tick.)

This species was found only at Bok, below Pensi La, where two males in much-worn plumage were taken on July 23, 1933, in the willow thicket.

Phylloscopus griseolus (Blyth)

This warbler occurs sparsely throughout Zankskar, but I did not find it in Purig. Specimens were first taken at Lagong.

Phylloscopus collybitus sindeanus (Brooks)

This is the common warbler of both districts, and it occurs around settlements and thickets wherever there is shelter. Full-fledged nestlings were taken in Purig. Through September individuals were still in the area.

Phylloscopus inornatus humii (Brooks)

In September the species occurs not uncommonly in migration. The last specimen was taken at Cha on September 25, 1931.

Tribura major major (Brooks)

Two were taken at Guntung, and there were others among the crops.

Sylvia althaea althaea Hume

In September, 1931, the species was a common migrant at Tetha and Cha from the 18th to the 25th. In 1933 it was found first about six miles above Sangu and then on down the valley, especially around Hippophae thickets. Specimens were collected at the localities mentioned.

Sylvia curruca blythi Ticeh. & Whistler

An adult female was taken at Sarle on September 20, 1931.

Monticola solitaria longirostris Blyth

An adult male was seen at Mune on July 18, 1933; one was taken at Sangu on the 26th and another at Guntung on the 27th. The

species apparently occurs locally in small numbers, as in the adjacent districts.

Myophonus coeruleus temminckii Vigors

In 1931 a specimen was seen at Tetha on September 20 and one was taken at Cha a few days later. In 1933 a bird in first plumage was collected at Parkachen on July 25. No others were seen, but the species probably nests occasionally elsewhere in Purig.

Oenanthe deserti oreophila Oberh.

Generally distributed in the valley floor as a breeding bird from Lagong to near Parkachen. Adults were much worn and juveniles were in first plumage. In September the species was still present in this situation, and most birds were in adult dress.

Saxicola torquata przewalskii (Pleske)

A male specimen was taken at Tetha on September 29, 1931. Wing measurement, 73 mm.

Saxicola torquata maura (Pallas)

Two females were taken at Cha, September 26, 1937. Wing measurements, 67 and 71 mm.

Phoenicurus ochrurus phoenicurioides (Moore)

Black redstarts were generally distributed, but not abundantly, on the way down to Rangdum in July, 1933. Adults were in badly worn plumage; the young were in first plumage. In September, 1931, the species was common at all localities, especially about villages.

Chaimarrornis leucocephala (Vigors)

In 1931 one was taken at Cha. In 1933 specimens were seen at Cha, Mune, and Yuljuk.

Luscinia pectoralis pectoralis (Gould)

The species frequents thickets along springs and is rather common from below Pensi La to Shakkar below Rangdum. Six males were collected, and all are typical of this form. Nestlings able to fly were taken after July 22, 1933. This area was visited after September 11 in 1931, but no specimens were seen.

Luscinia suecica abbotti Rich.

A female in first plumage was taken at Seni, and several others were seen. The species undoubtedly occurs elsewhere in both districts, especially in Purig, but there was no time to search for it.

Prunella rubeculoides muraria Mein.

Occurred sparingly in Zankskar from Lagong to Shakkar below Rangdum. A female in first plumage was taken at Lagong.

Cinclus cinclus cashmiriensis Gould

A pair was seen at Lagong on July 11, 1933.

Cinclus pallasii tenuirostris Bp.

A specimen was taken at Bok on September 13, 1931.

Delichon urbica (L.)

Generally distributed from Kargiak to Kargil in July, 1933. In September, 1931, it was present until the 15th.

Riparia rupestris (Scop.)

Distributed much as is the last species. In 1931 specimens were collected at Reru on September 18.

Apus apus (L.)

A flock of twelve was flying about Seni on July 21, 1933. In Purig swifts were common, especially in the lower part of the valley.

Apus pacificus (Lath.)

A single white-rumped bird that was probably of this species occurred with the preceding species at Seni.

Upupa epops epops L.

In 1931 specimens were taken at Reru and Cha in September. In 1933 the species was first observed at Sangu, where one was collected; several others were seen. They occurred then down the valley at the large villages.

Coracias garrulus semenowi L. & T.

On September 11, 1931, I found a dead bird, dry but with feathers intact, at Rangdum. Stragglers probably occasionally enter the area.

Cuculus canorus L.

Observed only at Yuljuk, where an adult male was taken on July 26, 1933. Cuckoos occur up to Leh, where I have taken specimens of the race *telephonus*; they are probably of regular occurrence in Purig. The Yuljuk specimen, compared with the type of *bakeri*, shows well the characters on which the form is based.

Falco peregrinus L.

A duck hawk was seen around the Phuktal monastery near Cha in September, 1931. The monks said a pair stayed there and ate pigeons.

Falco tinnunculus L.

Apparently generally but sparsely distributed in Zankskar. In 1933 it was seen at Kargiak, Cha, Mune, and Seni.

Accipiter nisus melanoschistos Hume

A female was seen at Yuljuk and another at Guntung in 1933. I make subspecific identification from a pair taken at Nimu, Ladakh, with a nestling, on August 3 and 4. The Yuljuk bird had prey and permitted close approach.

Circus aeruginosus aeruginosus (L.)

A specimen was taken at Cha in September, 1931, and later another was seen. One was taken at Hamiling on September 16, 1931.

Gypaetus barbatus (L.)

A specimen was seen at close range at Kargiak on July 11, 1933. Its underparts were nearly white. The species is common in Lahul, but was not elsewhere observed across the Great Range.

Gyps himalayensis Hume

A griffon was seen at Tetha on July 15, 1933. No others were observed.

Anas acuta L.

A flock of five were seen on a small pond near Rangdum on September 12, 1931.

Mergus merganser L.

In 1933 two were seen at Hamiling on July 21, and one was observed at Rangdum on July 24.

Columba livia neglecta Hume

A small flock was seen at Mune on July 18, 1933. In Purig it is common. Specimens were collected at Tsaliko.

Columba rupestris turkestanica But.

This is the common pigeon of the Zankskar; it was found about all settlements. It becomes scarcer below Tangola. Birds in first plumage were numerous in July, 1933. A Kargiak bird had its crop filled with a round soft madder-colored insect larva, about half as large as a pea, which an old man said it had found in the sand.

Columba leuconota leuconota Vigors

The snow pigeon is not rare between Kargiak and Lagong, where specimens were taken in 1931 and 1933. In 1933 five were seen at Rangdum and a similar number at Tangola. At Tangola all three species of *Columba* occurred together. These birds are less a species of the settlements than the others, and they appear to be rare. In Lahul they are said to descend from the hillsides in seeding time in flocks of hundreds.

Streptopelia orientalis meena (Sykes)

A stray male was taken at Abring on July 22, 1933. No others were seen till we reached Guntung, where they were not uncommon and where one was collected.

Charadrius mongolus atrifrons Wagl.

Plovers with young in down or half fledged were common around Padum on July 19, 1933. A few were seen at Abring also. In September none were observed in the district.

Calidris minuta (Leisler)

A male was taken at Rangdum on September 11, 1931.

Calidris temminckii (Leisler)

Specimens were taken at Rangdum on September 11, at Bok on

September 14, and at Kargiak on September 29, 1931. It is probably a not uncommon migrant.

Tringa totanus eurhinus Oberh.

The redshank breeds in the marshes about Rangdum and is not uncommon. Individuals were taken there in breeding dress on July 24, 1933, and in fall dress on September 11, 1931.

Tringa nebularia (Gunn.)

A specimen was seen on the spring pond at Seni with other sandpipers on July 20, 1933.

Tringa glareola L.

A few were seen at Seni, and one was taken in Purig above Parkachen.

Tringa ochropus L.

There were stray specimens about Rangdum and at Kargiak in September, 1931. In July, 1933, there were two at Seni; one of several seen at Rangdum was collected.

Tringa hypoleucos L.

Seen in 1933 at Hamiling, Seni, and Yuljuk, but not collected. At the latter place there were six in a flock.

Ibidorhyncha struthersii Vigors

An individual was seen at Seni and another at Hamiling. At Yuljuk there were three, of which one was collected. At Sangu the natives said they were not rare.

Sterna hirundo tibetana Saunders

A specimen was collected at Seni on the spring pond on July 19, 1933, and the next day five more were seen.

Tetraogallus himalayensis himalayensis Gray

Snow cocks were common at Kargiak near Ichor and at Hamiling in 1933. In 1931 they were seen above Rangdum and behind Sarle.

Alectoris graeca pallescens Hume

Chikor were common at Sarle and Cha in September, 1931. Some were only half grown. In 1933 they were seen only at Tetha, where one of about a dozen was collected. They are found in Purig also.

APPENDIX A

ADDITIONS TO THE AVIFAUNAL LIST OF LADAKH AND RUPSHU AS GIVEN
BY COLONEL R. MEINERTZHAGEN⁴ AND B. B. OSMASTON,⁵
AND NOTES ON SOME OTHER LITTLE-KNOWN SPECIES

I visited the district of West Tibet in the summers of 1931 and 1933. In 1931 Bara Latza was crossed on June 20, and the route to Tso Kar, Pologonka, Puga, Tso Morari, Tso Kyun, and Hanle was followed to Nima Mud on the Indus. Then the way went across Tsaka La to Shushal, along Pangong Tso to Trangse, and across Chang La to Leh. From Leh my route led to Lamayuru and up the Kangi Nulla to Kangi La and over to Rangdum in Zankskar. The Zankskar road led to Shingkun La, which was crossed on October 2. In 1933 the itinerary began at Shingkun La on July 10 and continued across Pensi La and the Rangdum River to Kargil. The rest of the journey included Likir, Leh, Tok, Hemis, Gya, Tso Kar, and Bara Latza, the last of which I crossed on August 25.

Specimens collected during the 1931 trip have been dispersed, and I am making use, for the most part, of notebook data. Those collected in 1933 are preserved in the Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Erythrina rubicilla severtzovi Sharpe

Erythrina rubicilloides lapersonnei Mein.

An adult male of each species was taken at Puga on July 5, 1931. Eggs of the former were found in the *drama* bushes. Both forms are known from Ladakh, but they have not been commonly taken at the same place during the breeding season.

Montifringilla blanfordi Hume

A juvenile and an adult male were taken at Tso Kyun, Rupshu, on July 11, 1931, and adults near Kiangchu (More Plain) a few days

⁴ Meinertzhagen, R., "Systematic Results of Birds Collected at High Altitudes in Ladakh and Sikkim," *Ibis*, Ser. 12, 3: 363-422, 571-633. 1927.

⁵ Osmaston, as cited in note 3.

earlier. On August 21, 1933, a pair of adults and a young one in first plumage were taken at Kiangchu at the same place where the species was found in 1931.

Emberiza icterica Eversm.

An adult in fall plumage was taken at Kiangchu on August 20, 1933. A specimen was taken in Zankskar in 1931.

Melanocorypha maxima Gould

This species was not uncommon in the wet meadow before Hanle, where there were nests with fresh eggs on July 13, 1931, and where several birds were collected. It had not previously been known to breed in the Indian Empire.

Phylloscopus inornatus humii Brooks

An adult male was taken at Cha, Zankskar, on September 25, 1931.

Cephalopyrus flammiceps flammiceps (Burton)

There was a flock at the mouth of the Kangi Nulla in September, 1931. One was shot, but the skin was lost.

Luscinia svecica pallidogularis (Zarud.)

A juvenile specimen in full first plumage was taken at Sakti on August 2, 1931. It is much different in coloration from the usual *abbotti* that occurs throughout Ladakh.

Coracias garrulus semenowi L. & T.

A male was collected at Spitok on August 19, 1931. A carcass was found at Rangdum in 1931.

Alceco atthis (L.)

A specimen was seen near Hanle on July 12, 1931. Osmaston records seeing one above Leh.

Cuculus canorus telephonus Heine

A juvenile in hepatic plumage was taken at Spitok on August 15, 1931, and an adult male at She on August 9, 1933.

Clamator jacobinus Bodd.

A male was collected at She on August 9, 1933.

Circus aeruginosus aeruginosus (L.)

A female was taken in Zankskar in September, 1931; also at Tso Kar on August 18, 1933. Babault (*Miss. Bab. Prov. Cent. de l'I. Rég. Him.*, 1920) records a specimen from Tso Morari.

Falco tinnunculus dörriesi Swann

A pale female with wing measurement of 277 mm. was taken at Spitok on August 24, 1931.

Athene noctua (Scop.)

One was seen on the dry hills near Tok on August 25, 1931, and another at Kiangchu on August 21, 1933.

Streptopelia decaocto decaocto Friv.

A specimen was collected at She in August, 1931.

Oenopopelia tranquebarica tranquebarica (Herm.)

A female was taken at Nimu on August 4, 1933.

Coturnix coturnix (L.)

A specimen was seen at Puga on July 5, 1931.

Larus ridibundus ridibundus L.

A female was taken at Spitok on August 22, 1931.

Charadrius leschenaulti Less.

A pair was seen near Kiangchu, Rupshu, on June 25, 1931. A female, with bare belly patch and feigning lameness, was taken at Tso Kyun on July 11, 1931. A fall-plumaged male was collected at Spitok on August 21, 1931, and another on August 5, 1933. I believe the species breeds regularly in Rupshu.

Charadrius dominica fulva (Gm.)

A specimen was collected from a flock of twenty along the Indus near She in August, 1931.

Terekia cinerea (Güld.)

I shot a female at Spitok on August 24, 1931.

Tringa nebularia (Gunn.)

A female was collected at Spitok on August 22, 1931.

Calidris testacea (Pall.)

Two males in full breeding plumage were collected on Tsakzhun Tso on July 22, 1931.

Calidris minuta (Leis.)

Two males were taken at Spitok on August 4 and 5, 1933.

Capella stenura (Bp.)

A specimen was taken at Tso Kar on August 18, 1931. This species has been recorded by Sharpe from Leh.

Himantopus himantopus (L.)

Two were seen at Tso Kar on August 18, 1933.

Ibidorhyncha struthersii Vigors

This was common on the Indus between Spitok and She in August, 1931. It is not rare in Zankskar and Purig, where its occurrence has been recorded by Osmaston.

Numenius phaeopus (L.)

A bird alighted on the plain beside the Indus at Spitok on August 21, 1931, and stayed there all day. It was very shy.

Numenius arquata (L.)

A specimen was seen on the plain beside the Indus at Spitok on August 21, 1931.

Chlidonias leucopareia indica (Steph.)

A specimen was taken along the Indus near Spitok in August, 1931.

Fulica atra L.

A lone bird was seen on the Tso Kyun on July 12, 1931.

APPENDIX B

ADDITIONS TO LIST OF KULU BIRDS AS GIVEN BY HUGH WHISTLER,⁶
AND ADDITIONAL NOTES ON OTHER SPECIES WHOSE STATUS IS
UNCERTAIN

Parus major planorum Hart.

Whistler reports *caschmirensis* from Kulu, but my specimens from this district have smaller wing measurements: 9 males, 68-72 mm.; 10 females, 63-70 mm. In other characters, too, they agree with Hartert's type. This form, which breeds in the lower foothills, was named from winter migrants and is smaller than *caschmirensis* of the high mountains.

Parus monticolus monticolus Vigors

This was a not uncommon species about Naggar.

Sylviparus modestus simlaensis Stuart Baker

Not common, but I took specimens at Shedupattar in October, 1930.

Trochalopteron erythrocephalum erythrocephalum (Vigors)

Common in winter in the thickets along the Beas near Kulu and also at Arsu and Bajaura.

Pomatorhinus erythrogenys Vigors

Though I have not taken the species in Kulu, on two occasions I saw specimens there; on the Chunagai Pass before Rampur City and farther beyond at Arsu.

Leioptila capistrata pallida Hart.

The species is rather common about Banjar, where specimens were taken in November, 1931, and January, 1933.

Turdoides terricolor sindeanus Ticeh.

These birds are common in the dry stretch below Luri Bridge, where specimens were taken on December 8, 1931.

⁶ Whistler, Hugh, "A Note on the Birds of Kulu," *Journ. Bombay Nat. Hist. Soc.*, 31: 458-485. 1927.

Fulvetta vinipecta kangrae T. & W.

Found locally in small flocks in winter at altitudes of about 5,000 feet. Four were taken at Banjar in December, 1932, and January, 1933.

Molpastes cafer intermedius (Jerdon)

The species is not rare in Seraj, and it occurs at Kulu also. I have taken specimens at Kulu, Bhuin, Larji, and Arsu, from November to June.

Pteruthius xanthochloris occidentalis Harington

Two males were taken on November 26, 1933, on Bushreo Pass, and other specimens were collected in the district in 1931. The species is not common, but in the winter a few can usually be found with every large tit flock.

Pteruthius erythropterus (Vigors)

A female was taken at Kulu, December 26, 1933.

Certhia familiaris hodgsoni Brooks

I have never found it common, but at least one specimen was taken above Naggar at 9,000 feet, in 1930, and one at Arsu on November 18, 1933.

Saxicola torquata przewalskii (Pleske)

Found not rarely around Kulu in December of 1932 and 1933. Wing measurements, 8 males, 74-78 mm.

Phoenicurus erythronotus (Eversm.)

In January, 1933, the species was rather common along the river at Kulu, and several were collected.

Phoenicurus erythrogaster grandis (Gould)

A pair was taken at Kulu in January, 1933.

Tarsiger chrysæus whistleri Ticeh.

This species is a not uncommon winter resident along the Beas. I have also taken birds in winter at Arsu and Banjar. Most of the specimens were in immature plumage.

Saxicoloides fulicata munda Van Tyne & Koelz

Whistler doubted that the species occurs in the district, but it is not rare in a little stretch below Luri Bridge. Specimens were taken there on December 8, 1931.

Turdus boulboul (Latham)

A male was taken at Kulu on January 9, 1933.

Turdus albocinctus Royle

This is a locally common bird, but it usually stays above 6,000 feet. Specimens were taken in Shim Nulla and Naggar Nulla.

Turdus rubrocanus rubrocanus Gray

A large flock was seen above Bathad on November 7, 1930, and specimens were collected.

Oreocincla mollissima simlaensis Stuart Baker

In winter this is a not uncommon bird along the Beas. Babault took a male, but did not give the subspecies.

Oreocincla dauma dauma (Latham)

A male was collected at Kulu on January 10, 1933. Whistler gives a sight record.

Prunella strophinata jerdoni (Brooks)

Not common. Specimens were taken at Banjar in December, 1932, and January, 1933; at Arsu in November, 1933.

Prunella atrogularis buttoni (H. & M.)

Rather common in winter. Specimens were taken at Arsu in November, 1933, and at Kulu in January and December of that year.

Zoothera monticola Vigors

A male was taken at Naggar on January 14, 1931. A specimen was seen above Bathad on November 29, 1933.

Muscicapa strophinata strophinata Hodgson

Seen occasionally in winter along the Beas and the Tirthan. I found them breeding above Halan in May, 1931.

Muscicapa ruficauda Swainson

A male was taken in Shim Nulla in May, 1931.

Muscicapula tricolor notata (Whistler)

Specimens were taken in the rhododendrons above Zana, at 10,000 feet, in May, 1931.

Chelidorhynch hypoxanthum (Blyth)

Not uncommon, singly or in pairs, at Kulu during the winter. Specimens were taken in December, 1932, 1933, and in January, 1933.

Niltava sundara whistleri Ticeh.

Four specimens were taken at Kulu in December, 1933.

Lanius schach tephronotus (Vigors)

A male was taken at Kulu, December 26, 1932; wing measurement, 98 mm.; a female was collected there on the same date, 1933; wing measurement, 95 mm.

Orthotomus sutorius guzurata (Latham)

Whistler records hearing the species once at Kulu. I saw three specimens there on December 12, 1933, and collected one.

Phylloscopus affinis (Tick.)

A few birds breed in the juniper scrub on the peaks above Katrain. I collected a male there on May 8, 1931.

Phylloscopus collybitus tristis Blyth

Occurs sparingly on the dry hillsides in Kulu and Seraj during the winter. Found rather more common than usual at Arsu in November, 1933. A pair was collected at Kulu on January 10, 1933. In ten Kulu specimens the second primary is between 7 and 8 or equal to 8, and in three specimens between 8 and 9. Whistler gives sight records.

Phylloscopus reguloides kashmiriensis Ticeh.

A breeding male was taken in Zana Nulla on May 25, 1931.

Horeites brunnifrons whistleri Ticeh.

Single males were taken above Katrain, at 11,000 feet, on May 8, 1931, and at Arsu on November 16, 1933.

Franklinia gracilis gracilis (Franklin)

Three males were taken at Arsu in November, 1933.

Cephalopyrus flammiceps flammiceps (Burton)

Specimens were taken at Naggar and above Katrain in May, 1931.

Regulus regulus himalayanus Jerdon

In summer this species was always found at about 9,000 feet above Naggar. In the winter of 1931 it was common at Banjar at 5,000 feet.

Pyrrhula aurantiaca Gould

Two males were taken at Banjar on January 3, 1933.

Procarduelis nipalensis nipalensis (Hodgson)

An adult male and immature birds were taken above Naggar, 9,000 feet, in October, 1930.

Callacanthus burtoni (Gould)

Numbers fed on the deodar seeds around Naggar in January, 1932. I have seen the species elsewhere only at Tarlognath, Chamba, where nestlings were taken in August, 1930.

Emberiza cia par Hart.

This form is not uncommon in the fall and winter. Specimens were collected in the districts of Kulu and Seraj in 1931, 1932, and 1933.

Emberiza fucata subsp.?

A female was taken at Arsu on November 20, 1933. Its wing measures 56 mm., which is much smaller than measurements given in Baker's *Fauna of British India*.

Anthus hodgsoni hodgsoni Richmond

A breeding male was taken May 8, 1931, at about 11,000 feet in Shim Nulla.

Anthus spinoletta coutellii Sav.

Flocks occur in winter along the Beas and in Seraj, chiefly on the rice fields, but also on the dry hills. I have seven specimens taken in December, 1932, and November, 1933.

Lalage melaschista melaschista (Hodgson)

I have found the species only at Katrain, where I collected specimens in 1931.

Aethopyga gouldiae gouldiae (Vigors)

Seen in the *nulla* above Naggar in April, 1931, feeding on flowers of *Rhododendron arboreum* and collected in Shim Nulla at 7,000 feet on May 5, 1931.

Dicaeum ignipectus ignipectus (Hodgson)

Whistler records two sight identifications of this species. It was common around Kulu in the mistletoe in December, 1932, and at Banjar in January, 1933. It was not common in Kulu in December, 1933.

Picus canus sanguiniceps Stuart Baker

Not common, but I have a few specimens: Naggar, May 6, 1931; Kulu, December 27, 1933.

Dryobates hyperythrus marshalli Hart.

Found commonly above Naggar at Shedupattar near the tree limit in October, 1930 and 1931.

Vivia innominata simlaensis Ticeh.

This is a not uncommon winter bird along the Beas near Kulu. I have also taken specimens at Banjar and Arsu in winter.

Cyanops asiatica asiatica (Latham)

A female was taken at Kulu on December 21, 1932.

Taccocua leschenaultii sirkee (Gray)

A male was taken at Luri on December 7, 1931.

Bubo bengalensis Franklin

Whistler reports sight records. On June 7, 1930, a nestling that appears to be of this species was collected above Naggar.

The great owl *B. turcomanus* occurs in the district above the tree limit on the Lahul and Spiti borders.

Glaucidium brodiei (Burton)

I found the species not rare at Zana, altitude 8,000 feet, on January 25, 1932. Singing specimens were heard at Saharan on November 26, 1933, and on the other side of the Bushreo Pass two days later. Specimens taken in Rampur-Bushahr are of the race *brodiei*.

Aquila nipalensis nipalensis (Hodgson)

Two that were feeding on a trout were shot near Manglor in December, 1930.

Hieraetus pennatus (Gm.)

Whistler quotes Donald, but records no specimens. A male was taken at Naggar on April 15, 1931.

Buteo buteo burmanicus Hume

On October 23, 1930, a male was taken at 9,000 feet above Naggar. On January 24, 1932, three males and a female were collected at Katrain. Wing measurements, males, 381-417 mm.; female, 417 mm.

Buteo rufinus rufinus (Cretzsch.)

A pale bird, a female, such as is common on the Punjab plains in winter, was taken at Arsu on November 15, 1933. Other such specimens have been seen in Kulu in winter, but the common form of this species wintering there is much darker than the bird of the plains. Examples, nearly alike in coloration, were taken: male, Katrain, January 24, 1932; female, Arsu, November 21, 1933; male, Kulu, December 24, 1933; female, Kulu, December 27, 1933.

Falco peregrinus peregrinator Sundevall

Seen by Whistler. An adult male was taken at Naggar on January 5, 1931.

Columba livia livia Gm.

Columba livia neglecta Hume

Whistler lists no subspecies, but it appears that the common form is *neglecta*. On December 27, 1933, a lone female was collected that

tracts are occupied by clumps of scrubby bushes. The Darba country is unirrigated and, because of several years of drought, was almost desert. In many places there are moving dunes, and only toward the Bikaner border does one find any ground cover.

The other major differentiated habitats are not apparent to the superficial observer. Owing to peculiar soil conditions certain plants grow only in regions where the summer rains make the waste fruitful; weed seeds, which are scattered there by the elements, form the winter food of many birds. For this reason one finds such birds as *Melanocorypha bimaculata*, *Columba oenas*, and *Pterocles orientalis* restricted to small parts of a large area that is apparently uniform in physical aspects.

The climate in winter is generally cool and pleasant. The nights are cold, and sometimes ice forms in the water basin. The days are not hot, and often one can wear a coat all day. After the first of March the heat begins to grow, and the snakes and insects come forth. There is then a stronger movement in the wintering bird population.

In the cold months the bird population of these areas is composed of a mixture of winter visitors from the northerly regions and of permanent residents. Considerable movement, especially noticeable on Parwali Lake, takes place from day to day. Species come and go, or flocks of a species pass over after a short rest. On the plains a given area may be frequented today by species that before had been found only a mile away, and so on.

Thanks to a plentiful supply of ground squirrels, hares, small birds, and fish, birds of prey are particularly common in the area.

Several naturalists have been very helpful to me during the preparation of this manuscript. Dr. C. B. Ticehurst has advised me on certain matters pertaining to nomenclature, and Mr. James Peters, Dr. Ernst Mayr, Dr. Josselyn Van Tyne, and Mr. Pierce Brodkorb have given generously of their time in comparing certain specimens with material in the collections under their care. I gratefully acknowledge my obligation to them.

LIST OF SPECIES

Corvus corax laurencei Hume

Not uncommon around the city of Sirsa, where refuse provided plenty of food. They occurred in the open country also. At Parwali

a pair came on March 7, 1933, to the bird carcasses around camp, and the cheels (*Milvus*) tried to chase them away. A raven slyly sidled up to a cheel and savagely plucked a primary. The cheel fell on its back in an attitude of defense. The raven repeated his attack on another cheel, and his enemy withdrew.

Corvus splendens zugmayeri Laubm.

Generally abundant. At Lahore in the winters of 1931 and 1933 there regularly occurred the roosting flight of crows that has been frequently described. About 5:45 P.M., from three northerly and three southerly directions, birds would begin flying in a line toward the forest; they continued till dusk. If five crows per second passed a given point and the flight lasted twenty minutes, 6,000 crows passed in each line. Three such lines were visible from camp, and three others entered from the opposite side of the woods. Scattered remains on the ground in the woods showed that the owls knew about the assemblage. At Sirsa the crows came to feed on the bird carcasses around camp by sunrise, and by 8 A.M. all had gone, leaving the remains of the food till night.

Dendrocitta vagabunda pallida (Blyth)

Occasionally seen at Lahore, where three specimens were taken on February 12 and 16, 1933.

Parus major planorum Hart.

Not rare in the groves and tree rows at Lahore. The race *caschmirensis* is usually recorded from Punjab, but my specimens (wing measurements, 67-72 mm.) are too small for this form; they agree with Hartert's type in all characters.

Turdoides terricolor sindianus Ticeh.

Occurred commonly in flocks, usually in the orchards. Wing measurements, 6 specimens, 104-111 mm.

Argya earlii (Blyth)

Taken only at Lahore, where flocks numbering as many as twenty-five birds occurred in the Shisham jungle and in the rushes about the oxbow. Wing measurements, 10 males, 90-95; 6 females, 88.5-92 mm.

Argya caudata caudata (Dum.)

Common and generally distributed in both districts, especially in the bushy stretches. Wing measurements, 16 males, 77-83 mm.; 13 females, 75.5-80.5 mm.

Argya malcolmi (Sykes)

Taken only at Sirsa. Wing measurements, 6 specimens, 113-119.5 mm.

Chrysomma sinensis hypoleuca (Franklin)

Found only at Lahore, where it was common in the grain fields near Shalamar Gardens. Wing measurements, 10 specimens, (60) 65-68 mm.

Molpastes cafer pallidus Baker

Occurred with the preceding species, but less common. Wing measurements, 6 males, 94-98.5 mm.; 3 females, 90-95 mm.

Molpastes leucotis leucotis (Gould)

Very common and generally distributed, at both Lahore and Sirsa. Flocks feed heavily on fruit. Wing measurements, 9 males, 80-89 mm.

Certhia himalayana limes Mein.

A few creepers in the mango gardens and Eucalyptus grove at Lahore. Specimens were collected on February 13 and 17, 1933.

Saxicola caprata bicolor Sykes

A common bird, usually found in the cultivated fields. Wing measurements, 8 males, 70-73 mm.; 8 females, 66-70 mm.

Saxicola torquata maura (Pall.)

Not uncommon in or at the edge of cultivation at Sirsa and Lahore; occurred singly or in pairs. Wing measurements, 5 males, 69-72 mm.; 13 females, 63-70.5 mm.

Oenanthe picata (Blyth)

Generally distributed like the last species, but much less common.

Oenanthe capistrata (Gould)

The only records are a male taken at Sirsa on January 29 and two females collected on January 25 and February 1, 1933.

Oenanthe opistholeuca (Strickl.)

Rather rare and seen only on the Sirsa plains. Wing measurements, 5 males, 89-94 mm.; female, 91 mm.

Oenanthe isabellina (Cretzsch.)

Distributed like *O. d. albifrons* and just about as common. Wing measurements, 4 males, 94-99 mm.; 2 females, 94 and 95 mm.

Oenanthe deserti atrogularis (Blyth)

Common and generally distributed on the bare fields and plains of both districts. Wing measurements, 9 males, 89-98 mm.; 11 females, 86.5-92.5 mm.

Oenanthe xanthopyrmyna chrysopygia (De Fil.)

Found only in 1931, near the Bikaner border on the dunes. One specimen was collected and others were seen.

Cercomela fusca (Blyth)

Seen once at Lahore, beside the Shalamar Gardens wall, and at Sirsa along with *Emberiza s. striolata*. It was not uncommon at Sirsa. Wing measurements, 2 males, 88.5 and 89.5; 3 females, 85-87 mm.

Phoenicurus ochrurus phoenicuroides (Moore)

Common and widely distributed in both districts. It frequented thick brush and also occurred at times with species of *Oenanthe* on the plains. Wing measurements, 8 males, 81.5-83 mm.; 3 females, 79.5-82 mm. The wing measurements of my Sind and Punjab specimens are much smaller than those of breeding hill birds of the Punjab and Ladakh.

Luscinia suecica pallidogularis (Zarudny)

Common in both areas; occurred among the irrigated crops, in the reeds, and also in thickets. Molt was nearly completed on specimens taken in March. Wing measurements, 17 males, 69-75 mm.; 7 females, 68-70 (73) mm.

Saxicoloides fulicata cambaiensis (Lath.)

Generally distributed and fairly common in both areas. Wing measurements, 7 males, 72-76 (78) mm.; 4 females, 71-74 mm.

Copsychus saularis saularis L.

Rare. The only records are of two males taken at Parwali on January 22 and 25, 1933.

Turdus atrogularis Temm.

Not uncommon at Lahore in the Eucalyptus grove, but only one was seen at Sirsa, a male taken on January 30, 1933.

Muscicapa parva parva (Bechst.)

Wintered sparingly at Sirsa in the cemetery grove and in orchards where there was a pool. At Lahore also it occurred in the latter sort of habitat. Wing measurements, 10 males, 65-71 mm.; 3 females, 66-67 mm.

Leucocirca aureola aureola (Less.)

Occurred in small numbers at Lahore and Sirsa, usually in the orchards. Elsewhere there was seldom to be found the dense foliage that these birds seem to like to dive about in. Wing measurements, 9 males, 82-85 mm.; 3 females, 76.5-82 mm.

Lanius excubitor lahtora (Sykes)

Common at Lahore and in the Sirsa district, usually on the open plain, where occasional trees or shrubs offer a perch. Wing measurements, 14 specimens, 111-116 mm. One of the specimens is like the race *pallidirostris* in the amount of black on the secondaries.

Lanius vittatus Valenc.

First specimen taken at Sirsa on January 28, 1933. From then until the end of February it was not observed. It was not uncommon in March. One was taken at Lahore on February 18.

Lanius schach erythronotus (Vigors)

Occasional specimens taken at Sirsa during all our stay. Wing measurements, 2 males, 89 and 90 mm.; 5 females, 88-96 mm. On two of the males the white spot at the base of the primaries is very faint.

Lanius cristatus isabellinus H. & E.

A common bird of the uncultivated areas.

Tephrodornis pondicerianus pondicerianus (Gm.)

Fairly common, usually in pairs or small parties in scattered trees or groves at Lahore. At Sirsa the species was rare, and the only two specimens, a pair taken on February 5, 1933, are of the *freta* race (wing measurements, 90 and 88 mm.). Wing measurements, 3 males, 89–91; female, 83.5.

Pericrocotus brevirostris brevirostris (Vigors)

Common at Lahore in February, 1933. At Sirsa a flock of about ten birds in female dress was seen on February 8. Wing measurements, 6 specimens, 92–94 mm.

Pericrocotus cinnamomeus iredalei S. B.

Rather common at Lahore in February, 1933. Wing measurements, 5 males, 66.5–72; 6 females, 66.5–70.

Pericrocotus erythropygia (Jerd.)

Three females taken at Parwali on February 4 and 5, 1933. These were the only specimens seen.

Dicrurus macrocerus macrocerus Vieill.

Generally distributed on the plains, usually at least in pairs, often accompanying grazing flocks. Wing measurements, 4 specimens, 144–150.5 mm.

Acrocephalus agricola agricola (Jerd.)

Occasionally seen at Sirsa in the grain fields. Only one specimen taken, March 10, 1933.

Locustella naevia straminea Seeb.

First observed at Parwali on March 7, 1933, in the grassy border of a dry canal. Birds were seen occasionally thereafter, but were flushed with great difficulty. Only one was collected.

Orthotomus sutorius guzurata (Lath.)

Occasional specimens found, chiefly in the gardens, throughout the winter. Wing measurements, 6 males, 50–54 mm.; 2 females, 49 and 50 mm.

Luscinola melanopogon mimica Madar.

Seen only at Lahore, in the reeds along the oxbow. Specimens were taken there on February 11 and 16, 1933.

Cisticola juncidis cursitans (Franklin)

Common around Parwali Lake in the grass and grain fields. Wing measurements, 9 specimens, 45-53 mm.

Franklinia buchanani (Blyth)

Common in the scattered scrub of the semidesert plains, at both Sirsa and Lahore. Males were singing. Wing measurements, 14 males, 50-56 mm.; 8 females, 47-54 mm.

Laticilla burnesii (Blyth)

Common in both districts. At Lahore it occurred in the broad stretch of grass clumps along the Ravi, but at Parwali it kept to totally different cover, namely, the short grass clumps and bushes that grew along the dry canals. Wing measurements, 9 specimens, 54-56 mm.

Hippolais rama rama (Sykes)

Not uncommon in the bushes and acacias at Sirsa. Wing measurements, 8 males, 59-64 mm.; 2 females, 59 and 62 mm.

Sylvia hortensis jerdoni (Blyth)

Rare; observed only at Parwali, where it was found singly in the acacias. Three males were taken on March 6 and 8, 1933.

Sylvia nana nana (Hemp. & Ehr.)

Found only at Sirsa, where it was always rare. Three males were taken in January, 1933. This bird was very restless, even shy, and occupied only the barest plains, where there were scattered stunted shrubs.

Sylvia althaea zagrossiensis Sar.

An adult male taken at Darba on March 15, 1933 (wing measurement, 66 mm.), has a very much smaller bill than typical *althaea* from Ladakh and also much less white on the outer pair of rectrices.

Sylvia curruca blythi Ticeh. & Whistler

Common and generally distributed at Lahore and in the Sirsa district; occurred in both trees and scattered bushes. Wing measurements, 15 males, 64-67 mm.; 3 females, 63-64 mm. Primaries 2 = 6-7; once 7-8.

Sylvia curruca minula Hume

Found at Sirsa, usually on the plains with scattered dwarf shrubs such as *Sylvia nana* frequented. Wing measurements, 5 males, 59-62 mm.; 4 females, 57-62 mm. Primary 2 = 7-8.

Phylloscopus collybitus tristis Blyth

Occurred commonly in small parties or singly at Sirsa and Lahore. Mustard fields were favorite forage grounds, but other crops were visited, and the species was observed in the trees also. Of the numerous specimens obtained about half might be considered *sindianus* if judged by the length of the second primary. In them 2 = 8-9 or 9-10. The coloring is rather more like that of *tristis*.

Phylloscopus griseolus Blyth

The first one seen was taken in an acacia tree on March 11, 1933. Thereafter specimens were collected at Darba, on March 14, where it occurred on the semidesert dune-strewn fields, and at Sirsa, on March 19, among the grain fields.

Phylloscopus subviridis (Brooks)

Few seen in the acacia trees at Lahore and Sirsa throughout the winter. They became somewhat commoner in March. Wing measurements, 8 males, 52-58 mm.; 4 females, 49-52 mm. Primary 2 = 8-9 or 7-8.

Phylloscopus inornatus humii (Brooks)

Few occurred regularly at Sirsa and Lahore in the trees. Wing measurements, 6 specimens, 53-58 mm.; second primary between 7 and 8 or equals 7.

Prinia gracilis lepida Blyth

Common at Parwali and at Lahore in the tall grasses. Wing measurements, 7 males, 42-46 mm.; 3 females, 42-44 mm.

Prinia flaviventris sindiana Ticeh.

Unsexed specimen taken at Lahore on January 26, 1931, along the Ravi. The bird is in poor plumage, and the race can only be guessed at. No others were seen.

Prinia socialis stewarti Blyth

Not uncommon at Lahore and Sirsa. Grain fields with hedge borders were favorite haunts. Wing measurements, 8 males, 45-53 mm.; 4 females, 45-48 mm.

Prinia inornata terricolor Hume

Common in the scrub of the plains and grassy thickets at Lahore and Sirsa. Wing measurements, 7 males, 50-53 mm.; 5 females, 47-49.5 mm.

Pastor roseus L.

Large flocks seen near the Bikaner border in 1931. In 1933 only a few occurred with the *Sturnus* flocks. Stray specimens were collected at Parwali on February 28 and on March 2, 7, and 8.

Sturnus vulgaris porphyronotus Sharpe

Not rare at Lahore, where seven specimens of this race were taken between February 16 and 18, 1933. At Sirsa, only one bird, a female, taken January 29, 1933, was observed. Wing measurements, 126-131 mm.

Sturnus vulgaris pollardtskii Finsch

The common form at both Lahore and Sirsa. Starlings were not common, however, at the latter place. Wing measurements, 14 specimens, 123-133 mm.

Acridotheres tristis tristis (L.)

Generally distributed and abundant, especially in the neighborhood of settlements.

Acridotheres ginginianus (Lath.)

Fairly common and generally distributed. It usually followed the herds on the plains, but occurred also on roofs in Sirsa.

Ploceus philippinus philippinus (L.)

Birds in winter plumage not uncommon in the rushy pools beside Shalamar Gardens. Specimens were taken between February 11 and 21, 1933. Wing measurements, 6 specimens, 67.5–70 mm.

Ploceus benghalensis (L.)

I have found this species only around wet reedy marshes in Sind and at Keshapur, north of Lahore. It was rather common in both localities.

Uroloncha malabarica (L.)

Generally distributed where grass seeds are available; occurred usually in small flocks. Wing measurements, 19 specimens, 53–56 mm.

Amandava amandava amandava (L.)

Locally distributed. Flocks occurred at Lahore along a grassy ditch, where they fed and roosted in the grass, and at Parwali. They are often kept as cage birds and are used, I am told, for sport. No males were seen in full plumage. Wing measurements, 13 specimens, 46–49.5 mm.

Gymnoris xanthocollis transfuga Hart.

First seen on March 2, 1933, when one was collected from a small flock at Ortu. By the middle of the month the species had become common, being seen most often in blossoming trees. Wing measurements, 15 males, 79.5–84.5; female, 77 mm.

Passer domesticus indicus Jard. & Selby

Generally distributed and abundant.

Passer pyrrhonotus Blyth

Found only at Lahore. In 1931 it occurred around a settlement near Shalamar Gardens, but in 1933 it was found only about a mile from there, in a place where a group of acacias grew around a pool. They fed on pampas grass seeds during the day and roosted in the acacias at night. Wing measurements, 11 males, 66–70 mm.; 8 females, 64–66 mm.

Passer hispaniolensis transcaspicus Tschusi

Occurred in flocks through the winter at and all around Sirsa. They fed on the dry plain and took refuge in the *Zizyphus* bushes. Often flocks of *P. domesticus* occurred in the same place, but I never saw mixed flocks. Wing measurements, 3 males, 80–81 mm.; 7 females, 76–82 mm.

Emberiza stewarti Blyth

Seen only at Parwali, where specimens were taken on February 6 and 28, and on March 1, 3, and 11, 1933.

Emberiza cia par Hart.

Occurred in flocks at Lahore and at Parwali, usually in the pampas grass jungle at Lahore. As is often true of subspecies of other Himalayan birds, this form differs sufficiently in voice and habit from *stracheyi*, the common Himalayan race, to compel attention in the field.

Emberiza striolata striolata (Licht.)

Small numbers on and around the high mound that lies beside Sirsa. The brickyard at Sirsa was another favorite spot. In its habitat *Cercomela fusca* was always to be found.

Motacilla alba dukhunensis Sykes*Motacilla alba personata* Gould*Motacilla alba alboides* Hodgson

Dukhunensis occurred commonly at Sirsa and Lahore during all our stay. *Personata* was much less common at both places, and *alboides* was rare. Adult specimens of *alboides* were taken at both localities.

Motacilla maderaspatensis Gm.

Occurred sparingly along the drying canals at Ortu and at Lahore. Wing measurements, 4 males, 96–100 mm.; 4 females, 90–91 mm.

Motacilla flava beema Sykes

First seen at Sirsa on February 23, 1933; in March it was abundant. Most of the males taken as late as March 19 had not yet completed their molt.

Motacilla flava thunbergi Bill.

Female taken at Sirsa on March 19, 1933; it appears to belong to this race.

Motacilla flava melanogrisea (Hom.)

Present in small numbers on our arrival at Sirsa, but not till after late February were they common. Occurred also at Lahore. Specimens taken in late February, 1933, had nearly completed their molt.

Motacilla citreola citreola Pall.

Motacilla citreola calcarata (Hodgson)

Motacilla citreola werae (But.)

In early February, 1933, at Parwali Lake flocks of wagtails scattered over the mud at night and made the lake lively with their sharp clear "cleek," like little chickens that had lost their mother. Sometimes they stopped on the sward in front of our camp. After our return to the lake on February 26 no such flocks were seen. On March 22 they were observed coming in huge flocks to roost in a stand of sugar cane at Sirsa. *Werae* was the commonest form seen at Parwali and Sirsa, but at Lahore *citreola* was apparently more abundant. *Calcarata* was not taken around Sirsa; rare at Lahore.

Anthus trivialis trivialis (L.)

Occurred in the grain fields at both Lahore and Sirsa. It was taken at the latter place only after February 24 and until March 19, 1933.

Anthus trivialis haringtoni Witherby

Male taken at Parwali on March 8, 1933; others at Lahore on February 9, 12, and 14.

Anthus pratensis (L.)

Lone female (wing measurement, 83 mm.) taken at Parwali on February 28, 1933. I did not see others.

Anthus sordidus jerdoni (Finsch)

Occurred sparingly, usually singly or in pairs, in the grain fields and at their borders. The first specimen seen was taken on February 23, 1933. A very dark bird was collected at Parwali on March 4.

Anthus rufulus rufulus Vieill.

Occurred sparingly at Lahore and Sirsa, and specimens were taken at both places.

Anthus campestris campestris (L.)

Six specimens from Sirsa, rather yellowish and less gray, which appear to belong to the typical race *campestris*. Wing measurements, female, January 21, 1933, 87 mm.; males, January 23, February 23 and March 7 and 17, 1933, 87-93 mm.

Anthus campestris griseus Nicoll

A very common bird on the dry fields. Usually it occurred in small flocks. Wing measurements, 34 males, 85-96 mm.; 16 females, 82-90 mm.

Anthus roseatus Blyth

Occurred commonly, usually in flocks, around Parwali Lake and at Lahore along weedy pools and the oxbow. Only one of ten collected specimens is a female. Several have the rosy throat of the adult. Wing measurements, 87-90 and 82 mm.

Anthus spinoletta coutellii Sav.

Occurred around the lake at Parwali and in the grain fields at Sirsa and Lahore. Flocks of five to eight were most commonly met. Wing measurements, 3 males, 89.5-91.5 mm.; 4 females, 82-88.5 mm.

Melanocoryphus bimaculatus bimaculatus (Menetr.)

Occurred near Sirsa in huge flocks in 1931, but in 1933 the species was scarce. Lone specimens were taken on January 28 and February 23. The bills of these birds are smaller than those of most Sind specimens of my collection.

Alauda arvensis intermedia Swinh.

Not rare in the grain fields at Lahore, and two pairs were collected. Wing measurements, males, 112 and 114 mm.; females, 106 and 108 mm.

Alauda gulgula punjaubi Whistler

Specimen taken at Lahore in the grain fields on February 12, 1933. At Sirsa the species was common in 1931, but was rare in 1933.

Calandrella brachydactyla longipennis (Eversm.)

Occurred at Lahore in large flocks and at Sirsa on the bare fields. They average smaller than Sind specimens and are more buff below. Wing measurements, 9 males, 91-94 mm.; two females, 88 and 89 mm. I think it possible that two races occur in Sind in winter.

Calandrella raytal adamsi (Hume)

Occurred only along the Ravi on the sand and in the adjacent fields. Large flocks were often seen there, February 10-22, 1933. Wing measurements, 9 males, 83-88 mm.; 8 females, 79-83 mm.

Galerida cristata chendoola (Franklin)

Generally distributed and common. Small flocks were usually found. Males were singing commonly after early February. Wing measurements, 19 males, 98.5-106 mm.; 13 females, 94-100 mm.

Eremopterix frontalis affinis (Blyth)

A male and a female collected near Darba on March 15, 1933. Otherwise the species was not observed. These two birds have larger and heavier bills than Sind specimens.

Zosterops palpebrosa occidentis Ticeh.

A common bird in the orchards at Lahore and Sirsa. They were usually found in small parties.

Cinnyris asiatica (Lath.)

Occurred sparingly during February in the vegetable gardens at Sirsa, feeding on the pea blossoms, and in the orange and other orchards. Males had not then begun to molt. On March 8, 1933, they were very common in Calotropis, which was coming into full bloom. Males were in full or nearly full plumage and were very vocal. At Darba, on March 14 and 15, 1933, there were fifteen or twenty in each tree of blossoming Bignonia. Collected specimens appear to be intermediate between the forms *asiatica* and *brevirostris*. Culmen measurements, 15 males, 14.5-17 mm.; 6 females, 14.5-16.5 mm. Wing measurements, males 55-58 mm.; females, 52-56 mm.

Piprisoma agile agile (Tick.)

A specimen taken at Sirsa in February, 1931; another on January 25, 1933. Otherwise the species was not observed.

Apus affinis affinis (Gray)

A colony of perhaps twenty-five had old nests under a bridge beside Shalamar Gardens on the Amritsar road. They came home to roost toward dusk. Seven specimens collected there on February 22, 1933, had eaten small beetles and flying ants. The species was not seen at Sirsa. Wing measurements, 4 males, 123–134 mm.; 3 females, 127–132 mm.

Caprimulgus mahrattensis Sykes

A male taken at Sirsa, February 13, 1931, on the desert plain. This is the only record.

Asio otus otus (L.)

Common toward Karnauli. Only one was seen at Sirsa. Wing measurements, male, 295 mm.; 7 females, 295–309 mm.

Asio flammeus leucopsis (Brehm)

In 1931 a flock of about six stayed in a small patch of scrub near Sirsa. In 1933 none were there, but specimens were obtained in other such places around Sirsa. Specimens were also taken along the Ravi in 1931. On February 26, 1933, a bird of this species tried to catch a bat. Another bat came to the rescue and both pursued the owl.

Bubo benghalensis (Franklin)

Only two specimens secured, both at Sirsa, one on February 10, 1931, and the other on February 5, 1933. In 1933 one was frequently seen around the great mound beside Sirsa. It undoubtedly resided in the series of holes that honeycomb this formation. Another was seen at close range in an acacia grove at Ortu on March 1, 1933.

Bubo coromandus coromandus (Lath.)

A common species in both districts. Half-grown young were found in nests after mid-January, but the gug gug gug gug of the males could be heard as long as we stayed at Parwali — till March 15. Stomach contents, January 29, 1933, grey tit; February 1, crow. Wing measurements, 7 males, 391–402 mm.; 10 females, 398–423 mm.

Otus bakkamoena gangeticus Ticeh.

A male taken in a *bher* tree at Lahore on February 10, 1933. No others were seen.

Athene brama indica (Franklin)

Common and generally distributed in both areas. Around Sirsa almost every suitable acacia tree housed a pair. In 1933 there was a pair beside our tent at Parwali. At the beginning they spent most of the day sitting outside the hole, but on our approach the male always hastily went inside. The female stayed out and on February 5 was shot. Next day her place was taken, and on February 28 the second wife was killed. On the morning of March 1 her place was taken. This bird was killed the next day. All day of March 3 the bereaved mate sat in the hole and from time to time emitted piteous feeble wails. On the 6th wife no. 4 had been found, and the normal impatient scolding tone of the husband was resumed. All the owls seen all winter were in pairs; where the mates were so readily obtained is not clear. Wing measurements, 4 males, 155–160 mm.; 9 females, 158–166 mm.

Aegypius monachus (L.)

Rare about Sirsa. In 1931 one was killed and two others were seen. In 1933 one occasionally came to camp to feed on our carrion. When it was there all other vultures made way. At Darba on March 16 a mated female was killed. The wing measures 727 mm.

Sarcogyps calvus (Scop.)

Not uncommon in both districts, but seldom seen in greater numbers than six. The wing of a female from Sirsa measures 593 mm.

Gyps fulvus fulvescens Hume

Occurred sparingly at both places. In my experience this great bird is always rare. One or two, however, are to be seen among every large assembly of vultures. They dominate the smaller species and feed first. The ravens, *Neophron*, and crows wait on the outskirts. The wing of a male taken at Sirsa measures 655 mm.

Pseudogyps bengalensis (Gm.)

The predominant vulture. At Lahore dark-rumped birds were in the majority, and it may be that *G. indicus* was among them. Wings of two adult females from Sirsa measure 554 and 599 mm.

Neophron percnopterus percnopterus (L.)

Common and generally distributed in both districts. It is the humblest-spirited bird in the region. A flock may always be seen hunting through the piles of dirt and rubbish that the sweeps bring out from the cities. For their chief food the crows are the only important competitors. Specimens taken in adult and immature dress.

Falco peregrinus babylonicus Gurney

Only a single bird observed, a male collected at Parwali Lake on March 3, 1933. Wing measurement, 292 mm.

Falco jugger Gray

Common, as hawks go, in both districts. One male has a heavily streaked breast. Wing measurements, 7 males, 320-337 mm.; 6 females, 356-373 mm.

Falco chicquera chicquera Daud.

Fairly common in both districts; always in pairs, usually near settlements where there were plenty of small birds. Wing measurements, 4 males, 196-201 mm.; 2 females, 224 and 233 mm.

Falco aesalon insignis (Clarke)

Only one specimen observed, an adult male killed at Parwali on February 5, 1933. Wing measurement, 204 mm.

Falco tinnunculus tinnunculus L.

Rather rare. Only three specimens, all males, were collected. Wing measurements, 238-248 mm.

Aquila heliaca heliaca Sav.

An immature bird taken at Lahore on January 16, 1931. At Sirsa only two adults, both females, were collected (Jan. 27, 1933, wing spread, 6 feet, 11 inches; Feb. 5, 1933, wing spread, 6 feet, 9 inches), but six birds in immature plumage were obtained. The

species was rather rare and was only occasionally seen. It is unmistakable in the field in any plumage. Food, January 27, tibia of small fawn or other grazing animal; February 1, a *Francolinus*. Wing measurements, 5 males, 562-585 mm.; 3 females, 590-614 mm.

Aquila nipalensis nipalensis Hodgson

Distributed like the last species but commoner. Wing measurements, 5 males, (505) 533-565 mm.; 2 females, 568 and 607 mm.

Aquila repax vindhiana Franklin

A common species in both districts. This and the preceding eagles fed regularly on the carrion about camp. The specimens collected show the extremes of light yellow brown and dark brown and many intermediate shades. Wing measurements, 20 males, 457-529 mm.; 18 females, 508-546 mm.

Aquila clanga Pall.

Rare. Only two specimens, females, were collected; Parwali, March 5 and 10, 1933. Wing measurements, 517 and 526 mm. At Gurdaspur lakes in 1931 the species was common.

Hieraaëtus fasciatus fasciatus (Vieill.)

A male in adult plumage was killed at Sirsa on February 4, 1931; wing measurement, 479 mm. A pair was taken at Parwali on March 10, 1933, both strong buff below with dark shafts, the stripes broader on the upper breast. The wing of the male measures 457 mm.; that of the female, 475.

Circaëtus gallicus gallicus (Gm.)

Not common. Seen only around Parwali, where four specimens were taken: January 28 and March 8, 10, and 20, 1933. The food of two specimens consisted of lizards.

Butastur teesa (Franklin)

Common in both areas, and widely distributed. Wing measurements, 4 males, 289-302.5 mm.; 3 females, 280, 290, and 310 mm.

Haliaëtus leucoryphus (Pall.)

Occurred in both districts, but always shy and collected with great difficulty. At Sirsa these birds sometimes came to the carrion

feast provided by our skinning operations. At Parwali and Ortu they were common, and fed heavily on the fish that swarmed in the drying canals, though here, too, they ate from camp at times. The distinctive call was heard daily. Specimens were taken in both adult and immature plumage. Wing measurements, 4 males, 551–592 mm.; 5 females, 597–630 mm. There is considerable variation in bill length among the specimens.

Milvus migrans lineatus (Gray)

A female taken on March 6, 1933, at Parwali; the only specimen definitely identified. Wing measurement, 511 mm.

Milvus migrans govinda Sykes

Abundant and generally distributed. Flocks visited camp daily for refuse. Some of the birds have conspicuous light-colored heads. Wing measurements, 6 males, 441–485 mm.; 2 females, 442 and 482 mm.

Elanus caeruleus (Desf.)

Seen only once; at Ortu on March 4, 1933.

Circus macrourus (Gm.)

Only rarely seen, but the regions were not particularly suited for harriers. Two males were taken at Parwali on February 6 and 28, 1933. Wing measurements, 330 and 364 mm.

Circus pygargus (L.)

An adult male seen on two occasions at Sirsa, on March 21 and 22, 1933. No specimens were collected.

Circus cyaneus cyaneus (L.)

Two males in immature plumage taken at Parwali on January 21 and February 5, 1933. Wing measurements, 339 and 341 mm.

Circus aeruginosus aeruginosus (L.)

Least rare of the harriers in both districts; always around water. All specimens taken and others seen were in immature plumage. Wing measurements, 2 males, 393 and 401 mm.; 2 females, 409 and 417 mm.

Buteo rufinus rufinus (Cretzsch.)

Common in both districts; occurred throughout the country, even in the desert, if a perch was available. Most of the specimens collected are pale, and none approach closely the dark birds that winter in the Kulu Valley. Wing measurements, 8 males, 416–439 mm.; 11 females, 439–467 mm.

Buteo buteo burmanicus Hume

A male (wing measurement, 389 mm.) taken at Parwali on March 5, 1933. No others were seen.

Accipiter badius dussumieri (Temm.)

Not common. Two males were collected at Lahore and a pair at Sirsa. Wing measurements, 3 males, 183–186 mm.; female, 210 mm. These birds are darker than the breeding form in the lower Kangra Valley.

Pernis apivorus ruficollis Less.

A single bird was seen, a male collected at Parwali on March 4, 1933. Wing measurement, 412 mm. The specimen is darker than any of the eight birds of my collection from the Kangra Valley and from the Sind. Its dark tail bars are the narrowest of the lot and its outer ones the longest. The stomach contained larval bees.

Columba eversmanni Bonap.

Flocks seen at Parwali and along the Ravi. On February 4, 1933, there were flocks totaling several hundred at Parwali; on March 2 there were flocks of from twenty to fifty. On February 17 a flock of about fifty was seen near Lahore. Wing measurements, 7 males, 195–209 mm.; 5 females, 187–203 mm.

Columba livia neglecta Hume

Common and generally distributed in both districts. At Sirsa it was found nesting in the wells, which are brick-lined, three feet in diameter and fifty or more feet deep. One pigeon had a nest a foot or two above the water, where a brick had fallen out of the wall.

Streptopelia chinensis suratensis (Gm.)

The least common representative of the genus, but found in small numbers at both places.

Streptopelia senegalensis cambaiensis (Gm.)

Common and generally distributed in both districts. Usually occurred in small flocks. Wing measurements, 7 males, 123-134 mm.; 6 females, 121-127 mm.

Streptopelia decaocto decaocto (Friv.)

Abundant and generally distributed in both districts. At Parwali at sunrise in early March, 1933, the entire horizon vibrated with the call of the singing birds. On March 4 and 5 four sang in the light of a half-moon till 9:30. Wing measurements, 11 males, 158-173 mm.; 7 females, 157-167 mm. A very pale *gugti* was seen among the others at Sirsa on February 25, 1933, but was so shy that we could not shoot it.

Oenopopelia tranquebarica tranquebarica (Herm.)

In 1931 in early March flocks of this species appeared at Sirsa. In 1933 none were observed.

Pterocles orientalis orientalis (L.)

Imperial sand grouse or *kashmiri* occurred abundantly on the dry plains toward the Bikaner border. They sometimes came as near as Sirsa. They fed in flocks, usually of about a dozen. At Parwali these flocks came to drink in the early morning. On February 4, 1933, several hundred came; on the 6th, at least a thousand. On March 1 they flew over in flocks of from five to ten, but seldom stopped. On March 14 one was seen at Darba. Wing measurements, 11 males, 227-251 mm.; 3 females, 222-230 mm. In the *Memoirs* of Jehangir a game bird is mentioned that can be caught near Delhi in huge numbers by imitating its call. The Kashmiris, he says, are very adept at this imitation. The local name for the bird may be associated with the custom.

. *Pterocles senegalensis hindustan* Mein.

Common at Sirsa. In January and February the flocks fed with the imperial grouse toward the Bikaner border, but by mid-March they were around Sirsa. We never saw them drinking at Parwali. A female taken on March 9, 1933, had an egg ready to lay. Wing measurements, 9 males, 171-187 mm.; 8 females, 167-173 mm.

Pavo cristatus L.

Common about Sirsa and all Hindu villages elsewhere. There are none around Mohammedan villages, but at Parwali, a Mohammedan center, they sometimes roosted in trees and were common in the surrounding country, where dense cover afforded shelter. Birds in female dress predominated everywhere. Not more than one bird in twelve could be identified as a male.

Coturnix coturnix coturnix (L.)

Generally distributed in both districts; usually flushed from the grain fields in pairs. Wing measurements, 14 males, 102–112 mm.; 2 females, 109 mm.

Francolinus francolinus asiae Bonap.

Occurred sparingly in both districts. Around Sirsa it was particularly rare. During March, 1933, a male sang regularly beside our camp at Parwali. He was seen singing in a tree on March 5. Wing measurements, 7 males, 151–159 mm.; female, 157 mm.

Francolinus pondicerianus interpositus Hart.

Common and generally distributed in both districts. It is often kept as a cage bird in the cities. Two were found roosting side by side near dark on February 26, 1933, in an acacia about twelve feet from the ground. Wing measurements, 21 males, 136–152 mm.; 21 females, 132–144 mm.

Grus grus lilfordi Sharpe

Flocks of *kunj* were to be seen or heard almost daily around Sirsa. On March 5, 1933, at least three hundred alighted on the lake. They came in four flocks and left in small groups next morning before sunrise. Each group followed the next at an interval of about a minute till all were gone. All went toward the west in one direction. In 1931 I witnessed a phenomenal assembly of this species. The flocks gathered from all around until the ground on all sides was blue with birds. At least a thousand must have been assembled. The flocks feed usually on the *channa* pods and doubtless cause considerable loss to the cultivators. Only one specimen, an adult male, was taken in 1933. Wing measurement, 565 mm.

Grus antigone antigone L.

Occurred in pairs or flocks up to nine around Parwali Lake. They often came to spend the night on the lake. Occasionally during the night their call resounded, answered invariably by a *Bubo coromandus* that had a nest near by. They always left at dawn. The natives in the Sirsa area have no strong objections to the killing of the species. A young bird taken on January 23, 1933, had the head completely feathered. The head and the upper half of the neck were rusty. Wing measurements, 4 males, 640–660; female, 599 mm.

Grus leucogeranus Pall.

On March 12, 1933, a hunter brought in an adult male white crane that he had killed near Karnauli, where it had been accompanied by its mate and a huge bird that answered the description of the adjutant which we observed on the same day. The crane had had its leg broken on a previous occasion. I had never before seen the species, and none of the natives questioned knew it. Wing measurement, 626 mm.

Anthropoides virgo (L.)

The first demoiselle crane, an adult female, was seen on Parwali Lake on February 26, 1933, and was collected next day in a *channa* field, where it had gone to feed with two bar-headed geese. Only one other bird of the species was seen — an adult male collected on March 3. The natives say that they pass through in great flocks in the fall. Wing measurements, male, 477 mm.; female, 480 mm.

Chlamydotis undulata macqueenii (Gray)

Not rare in the drier parts around Sirsa. The *channa* fields scattered about in the dry plains are favorite haunts. Wing measurements, male, 402 mm.; 6 females, 349–372 mm.

Choriotis nigriceps (Vigors)

Three great bustards seen at close range in 1931 at Jorawala, near the Bikaner border. We visited the same region in March, 1933, but found none.

Burhinus oedicnemus indicus (Salv.)

Not uncommon toward Karnauli. A female taken on March 10, 1933, had an egg ready to lay. Wing measurements, 3 males, 219–224 mm.; 4 females, 213–225 mm. Hartert considers Hissar specimens *astutus*.

Cursorius cursor cursor Lath.

Not rare in the dry dune country between Sirsa and the Bikaner border; singly or in flocks up to ten. Wing measurements, 13 males, 154–169 mm.; 2 females, 158 mm.

Glareola lactea Temm.

Occurred along the Ravi in 1931. On February 27 they were common at Parwali Lake. By March 9 they had all left. Wing measurements, 6 males, 150–161 mm.; 10 females, 145–156 mm.

Larus genei Brème

A single specimen collected; it came to Parwali Lake on March 9, 1933, and was a young male in winter dress, with some of the lesser wing coverts of the juvenile plumage.

Sterna melanogaster Temm. & Lang.

Seen commonly at Lahore, but rarely at Sirsa. No specimens collected in 1933.

Sterna aurantia Gray

Generally distributed like the last species. One taken at Parwali on February 4, 1933.

Charadrius alexandrinus alexandrinus L.

Small flocks seen almost daily at Parwali on the lake. Many of the birds had the rusty crown of adult plumage. Wing measurements, 10 males, 108–113 mm.; 8 females, 106–114 mm.

Charadrius dubius curonicus Gm.

The commoner of the two forms. Seen only at Parwali, from February 28 to March 10, 1933. Wing measurements, 5 males, 110–124 mm.; 4 females, 110–119 mm.

Charadrius dubius jerdoni (Legge)

A female (wing measurement, 106 mm.) taken at Parwali on March 9, 1933, may belong to this race.

Vanellus vanellus (L.)

Occurred along the Ravi in 1931 and in February, 1933. A flock of ten was also seen at Parwali on February 6, 1933. These birds did not come to the mud with the other snipes, but fed on the dry fields bordering the lake. They were very shy, and none were collected in 1933.

Chettusia gregaria (Pall.)

Not rare around Sirsa in 1931, where flocks of up to twenty birds were seen. They frequented the patches on the meadows that were once wetter than the surrounding land. In 1933 none were seen in these places and only two elsewhere: one at Parwali on February 3 and one at Ortu on March 4. None were collected in 1933.

Chettusia leucura (Licht.)

Common in the lake at Parwali. Wing measurements, 11 males, 170–181 mm.; 3 females, 173–179 mm.

Lobivanellus indicus aigneri (Laubm.)

Common and generally distributed in both districts. It was regularly heard at night even at Darba, where it seemed that there was not a drop of water. My specimens are much like those of Sind, and I follow Ticehurst in nomenclature. Wing measurements, 6 specimens, 222–226 mm.

Lobipluvia malabarica (Bodd.)

A single specimen observed, brought in by a collector from Kar-nauli on March 10, 1933.

Himantopus himantopus himantopus (L.)

Occurred commonly on Parwali Lake and on almost all the small ponds around Sirsa. Without exception the birds seen had heavy dusky markings on the head. Wing measurements, 8 males, 236–248 mm.; 7 females, 213–227 mm.

Recurvirostra avosetta avosetta L.

A lone avocet appeared at Parwali Lake on March 1, 1933. It stayed and was captured on the 5th. No others were seen.

Limosa limosa (L.)

A godwit that probably was of this species came to Parwali Lake on March 5, 1933. It was very shy and did not spend the night there.

Tringa ochropus L.

Common and generally distributed, either around the lakes or along rivers or in dirty mud puddles. Wing measurements, 5 males, 139–147 mm.; 6 females, 142–145 mm.

Tringa stagnatilis Bechst.

A few present daily on Parwali Lake.

Tringa glareola L.

Common in both districts, either singly or in small parties, scattered among the other waders.

Tringa totanus eurhinus Oberh.

A few at least were always present on Parwali Lake. A male taken on February 28, 1933, was in nearly full breeding dress. Others had not begun to molt.

Tringa erythropus Pall.

Flocks of up to a hundred of this very shy species often visited Parwali Lake. They also fed along the drying canals at Ortu. Wing measurements, 3 males, 162–173 mm.; 4 females, 164–173 mm.

Tringa nebularia (Gunn.)

Not uncommon along the oxbow at Lahore, at Parwali Lake, and along the canals at Ortu. Wing measurements, 3 males, 187–197 mm.; 3 females, 193–198 mm.

Tringa hypoleucos (L.)

Occurred in small numbers at Parwali.

Philomachus pugnax (L.)

Occasionally flocks of about fifty visited Parwali Lake. One was taken on February 12, and one on March 1, 1933.

Calidris minuta (Leisl.)

A flock seen almost daily on Parwali Lake, often mixed with dunlins. Wing measurements, 9 males, 91-99 mm.; 8 females, 94-99 mm.

Calidris temminckii (Leisl.)

Usually associated with the flocks of the preceding species, but less common. They occurred at Lahore in small flocks along the oxbow, where specimens were taken on February 11 and 19, 1933.

Calidris alpina alpina (L.)

A small flock seen almost daily on Parwali Lake. Wing measurements, 2 males, 115 and 116 mm.; 4 females, 112-118 mm.

Capella gallinago gallinago (L.)

At least a few specimens usually to be seen at Parwali Lake. Sometimes they all left for a few days. On March 10, 1933, the largest flock was seen there. The species also occurred at Lahore. Wing measurements, 3 males, 128-136 mm.; 3 females, 127-131 mm.

Lymnocyptes minima (Brünn.)

Occasional specimens along the oxbow at Lahore and on Parwali Lake, but none were collected.

Pelecanus crispus Bruch

At Parwali on February 26, 1933, two birds of this species appeared. They stayed there till March 12.

Phalacrocorax carbo sinensis (Shaw)

A flock of about fifty rested all day in a pond beside the city. At evening they came to the Ortu canals to fish and by 8 A.M. were on their way back. The first specimens were collected on March 6, 1933. One had a white thigh patch but no white head feathers. Another had a scattering of white on the breast.

Anhinga melanogaster Penn.

A single bird seen in a tree beside a pond near Sirsa on January 29, 1933.

Platalea leucorodia leucorodia L.

Taken at the Ravi near Lahore in 1931. Common at Parwali and a daily visitor on the lake. Four collected on March 5, 1933, contained only fish remains, chiefly otoliths and bones. One had twenty-five small ear stones. Usually from ten to thirty visited the lake, but on March 8 about sixty arrived; on the 10th, fifty. Wing measurements, 5 males, 362–383 mm.; female, 362 mm.

Pseudibis papillosa papillosa (Temm. & L.)

In 1931 a flock of at least fifty was flushed from the trees at a village near Sirsa. In 1933 only one was seen — a young male collected at Sirsa on February 24.

Ciconia ciconia asiatica Sever.

Seen only at Parwali. First observed on February 26, 1933, when one landed. On March 6 a small flock flew over, but on March 9 about a hundred came to the lake. A collected male had in its stomach fourteen fish 10 inches long. Wing measurement, 585 mm.

Dissura episcopus episcopus (Bodd.)

Rather common at Sirsa. They came to Ortu at night to fish but disappeared during the day.

Xenorhynchus asiaticus asiaticus (Lath.)

Rather common at Sirsa. They fed wherever any water remained, often following along the mud in dried canals. Occurred singly or in flocks up to twenty. Very shy. A male taken on March 7, 1933, measures $75\frac{1}{2}$ inches from tip of bill to tip of toes. Its food was chiefly cattle dung, but it contained a fish also. Wing measurements, 2 males, 597 and 602 mm.; female, 548 mm.

Leptoptilos dubius (Gm.)

On March 12, 1933, an adjutant appeared and started to fish in Parwali Lake. It was very shy and soon left.

Ibis leucocephalus leucocephalus (Penn.)

Observed only at Parwali. They first appeared singly on February 8, 1933. On March 3 about a hundred landed on the lake. The first juveniles appeared on March 12. Two specimens taken on February 28 had dung of cow or sheep in the stomach and one had a small fish. The adults taken often had the neck feathers badly worn. Juveniles have no trace of pink and except for the characteristic bill might be taken for some other species.

Ardea cinerea cinerea (L.)

Common in both areas. At Parwali there was a flock of from twenty to fifty of these birds that stayed all day on the lake. They left at night to fish in the canals at Ortu. They were always extremely wary. Only an adult male and a young female were collected.

Casmerodius albus (L.)

One specimen came to Parwali Lake on February 6, 1933.

Egretta garzetta garzetta (L.)

Not uncommon in both areas. Six were feeding on Parwali Lake on February 3, 1933.

Bulbulcus ibis coromandus (Bodd.)

A few present in the rushes along the river at Lahore.

Ardeola grayii (Sykes)

Common and generally distributed in both regions, usually in dirty ponds and weedy ditches. Wing measurements, 4 males, 196-222 mm.; female, 199 mm.

Sarkidiornis melanotus (Penn.)

One specimen seen in the Lahore market on January 8, 1934.

Anser indicus (Lath.)

Seen only at Sirsa. A few were frequently present on Parwali Lake in 1933. They were last seen there on March 10, when thirteen came. Sometimes a flock of fifty or so flew over. In Lahore markets on February 22 there were fifteen. Two were collected at Parwali.

Casarca ferruginea (Pall.)

Occurred on the Ravi and on Parwali Lake. They were abundant at Parwali on February 27, 1933. None were taken.

Anas platyrhynchos platyrhynchos L.

Observed in abundance at Ortu on March 1, 1933, and at Parwali on the 8th. One was collected.

Anas poecilorhynchos poecilorhynchos Forst.

On March 5, 1933, I saw what I felt sure was a pair of these ducks at Parwali. I have otherwise seen the bird in the district only in the takes of the netters, who bring them occasionally to the Lahore market.

Anas crecca crecca L.

Very common at Lahore and around Sirsa. If ducks occurred anywhere they were either all teal or had some teal among them. A census of the Lahore market on February 22, 1933, gives a fair sample of the abundance of the various duck species: *Casarca ferruginea*, 15; *Anas platyrhynchos*, 5; *A. crecca*, 30; *A. penelope*, 1; *A. strepera*, 2; *A. acuta*, 15.

Anas acuta acuta L.

Observed in abundance on Parwali Lake on March 8, 1933. One specimen was collected.

Anas strepera L.

Rare and seen only at Parwali, in March, 1933. Two were collected.

Anas penelope L.

A few seen in the mixed flocks of ducks at Parwali in March, 1933. One specimen was taken.

Spatula clypeata (L.)

Observed in abundance at Ortu on March 1, 1933. Three specimens were collected.

Nyroca fuligula L.

A male was seen on Parwali Lake on March 5, 1933. No specimens were taken.

Podiceps ruficollis (Vroeg.)

One seen daily on a pond beside Sirsa in February, 1931. Attempts to shoot it were futile. It dived, and though there were no rushes or water weeds it never reappeared till I had left. At Lahore they were common in the oxbow.

UNIVERSITY OF MICHIGAN

THE USE OF BRUSH SHELTERS BY FISH IN DOUGLAS LAKE, MICHIGAN *

IMMANUEL A. RODEHEFFER

AT THE 1938 meeting of the Michigan Academy the writer presented the results of studies made in 1934 and 1937 on the use of brush shelters by fish in six Michigan lakes (Rodeheffer, 1939). During the summer of 1938 the investigation was continued at Douglas Lake, Cheboygan County, Michigan, with the same shelters and the same methods of determining fish populations in or about the shelters and control areas that had been used in 1937. Details of the methods employed and the purposes of the study were stated in the previous paper. Further tests were needed to warrant the drawing of definite conclusions on several phases of the work undertaken in 1937.

In 1937 the fish populations about the shelters by day and by night showed differences that seemed to justify further day and night seining during the summer of 1938.

It had been realized for some time that additional study was needed to test the value of fertilizing shelters in order to make them more suitable habitats for fish. Therefore, in both 1937 and 1938 certain shelters at Grapevine Point in Douglas Lake were fertilized with barnyard manure.

The results of the studies outlined above are given here. A report on the use of brush shelters as a continuous summer habitat, as well as information regarding the movements of fishes (which it is hoped may be successfully determined by tagging and fin clipping), will be delayed, pending the completion of further investigations.

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INSTALLATION OF SHELTERS IN 1938

In 1937 ten shelters were placed in Douglas Lake at Grapevine Point. In a further effort to ascertain the relation of the brush shelters to the concentration and localization of the fish populations in given parts of a lake four additional shelters were placed just north of Hook Point in North Fishtail Bay in 1938. In this location the depth gradually increases to 8 to 12 feet at the drop-off, which lies 150 to 200 feet from shore. The bottom of the shoal, composed chiefly of sand, is covered by a layer of flaky marl ranging in thickness from a small fraction of an inch to about two inches and is almost devoid of rooted vegetation in water less than eight feet deep. In deeper water on the shelf near the drop-off and on the steep slope beyond there is some submerged vegetation.

The shelters, constructed according to directions by Hubbs and Eschmeyer (1938), comprised a hollow-center square shelter (22×22 feet), a pole shelter (18×26 feet), a ladder shelter (14×16 feet), and a circular shelter (12 feet in circumference). With the exception of the square and the pole shelters, which were separated by a distance of 200 feet to provide a control area, the structures were placed approximately 90 feet apart. They were larger and were less densely packed than those used at Grapevine Point in 1937 and 1938. They were too large to be entirely pulled out of the lake during the seining, but the clearness of the water made it possible to see that no fish stayed in the brush when brought to the shore.

In the area where these shelters were later placed four seine hauls made on July 20, 1938, with the 140-foot seine which had been used in 1937, caught 2 small-mouthed bass, 9 sand shiners, 3 spot-tailed shiners, 1 blunt-nosed minnow, 79 clams, and 1 crayfish. The results of this seining agree with those of similar seining at Grapevine Point in 1937 in confirming the general observation that such shoal areas in Douglas Lake are relatively barren of fish life.

RESULTS OF SEINING IN 1937 AND 1938

Data were obtained on the number of fish of each species taken per seine haul about the shelters and in the control areas (Table I). The results at Grapevine Point for 1937 and 1938 are in essential agreement. Rock bass, perch, pumpkinseed sunfish, small-mouthed bass, and large-mouthed bass, which were the common game species, ranked in abundance in the order given. Considering together the

TABLE I

NUMBER OF FISH OF EACH SPECIES TAKEN PER SEINE HAUL ABOUT
SHELTERS AND IN CONTROL AREAS IN DOUGLAS LAKE

Numbers in parentheses indicate number of seine hauls.

Values less than 0.05 are designated "tr." (trace).

SPECIES OF FISH	Grapevine Point 1937		Grapevine Point 1938		North Fishtail Bay 1938	
	Shelters (36)	Controls (23)	Shelters (40)	Controls (23)	Shelters (15)	Controls (4)
GAME FISHES						
Rock bass	40.7	0.4	39.6	1.2	24.8	2.0
Yellow perch	14.4	8.7	34.3	25.7	13.5	31.7
Pumpkinseed	7.0	1.0	7.6	0.9	17.6	2.8
Small-mouthed bass .	4.4	3.1	3.0	1.9	3.9	6.5
Large-mouthed bass .	0.6	0.1	0.2	tr.	4.3	0.8
Northern pike	...	...	0.1	...	0.2	...
Bluegill	0.1	...	...	...	...	...
COARSE FISHES						
White sucker	1.7	2.0	2.3	0.5	4.5	1.5
Brown bullhead	0.1	...	0.1	...	1.6	...
FORAGE FISHES						
Common shiner	0.7	0.7	3.6	2.3	0.9	11.5
Spot-tailed shiner	2.2	5.2	2.6	2.0	4.3	2.5
Log perch	1.6	2.5	3.0	1.0	1.3	0.8
Sand shiner	0.6	0.3	1.7	1.3	...	...
Blunt-nosed minnow ..	0.1	0.1	...	...	2.8	...
Johnny darter	0.3	0.8	0.3	0.2	0.5	0.8
Trout-perch	0.1	...	tr.	...	...	...
Iowa darter	tr.	0.1	...	...	...	...
Muddler	...	...	...	...	0.1	...
Total fish	74.6	25.0	98.4	37.0	80.3	60.9

results of the day and night seinings (as presented in Table I), one sees that rock bass and pumpkinseeds displayed a very strong preference for the brush devices, whereas perch, small-mouthed bass, and most other fishes were not consistently attracted to the shelters.

As would be expected (Hubbs and Bailey, 1938), the number of large-mouthed bass taken per seine haul in the quieter, weedier, and more roily waters of North Fishtail Bay was greater than at Grapevine Point, which is more exposed. All data indicate that this species showed a decided preference for the brush rather than for the open shoals. The relative numbers of small-mouthed bass taken in the covers and in the control areas of the two habitats are not so easily explainable.

Although Douglas Lake has a fairly good reputation for pike fishing, no northern pike were obtained in the seinings in 1937. In 1938 only one was caught at Grapevine Point, but it was recaptured several times, and only three were seined at North Fishtail Bay. Apparently pike do not inhabit brush shelters, or, at least, those located in comparatively shallow water.

The total number of fish taken per seine haul in 1938 was higher in both shelters and control areas than in 1937. This result may largely be explained by the greater amount of night seining in 1938, in which perch were taken in larger numbers than in the daytime.

THE REPOPULATION OF BRUSH SHELTERS AFTER THE REMOVAL OF ALL FISH

To determine to what extent and how rapidly brush shelters are repopulated all fish removed from the shelters and control areas north of Hook Point were carried in a straight line a distance of about 0.6 mile across North Fishtail Bay and were released in the small sheltered bay which lies to the east of East Point. All game fish of sufficient size were marked with numbered jaw tags, in the manner described by Shetter (1936), to permit identification of any that returned to the artificial covers. These shelters were removed fifteen times and the control area was seined four times between August 3 and 22, 1938. The number of fish taken per haul in North Fishtail Bay (see Table I) represents, therefore, new arrivals on the seining grounds. Nevertheless, the indicated abundance of fish here compared favorably with the determinations for Grapevine Point,

where the fish seined were not transported to another locality. Although the conclusion is weakened by the fact that the experiment and the control were performed in different parts of the lake, with distinctive conditions, the data suggest that fish may concentrate to a certain degree in areas provided with brush protection, and that if these fish are removed others take their place until the original concentration is approximately duplicated. However, the number of rock bass taken in hauls after the initial removal was always less than in the first seinings. Nineteen of the 497 fish tagged and planted across the bay were retaken in the shelters.

GAME FISH TAKEN ABOUT BRUSH SHELTERS AND
IN CONTROL AREAS BY DAY AND BY NIGHT

By quantitative seining in Douglas Lake many data were gathered on the number and size of individuals of each species of game fish found in and about the brush shelters and in the control areas by day and by night (Tables II-III). Marked differences were discovered in comparing the species and in contrasting the data for shelters and control areas and those for day and night occurrences of fish.

As previously stated, rock bass (Table II) congregated in notable abundance about the brush, though only during the day. At night about three fourths of them deserted the cover, but at no time were commonly seined in the control areas. Therefore at night they must either have scattered over the shoals (as suggested by the greater number there at that time) or have moved into deep water. In the control areas as well as about the brush the rock bass seined by day averaged larger than those taken at night. Less than 7 per cent of the 3,345 rock bass from about the brush were of legal size (6 inches). In Douglas Lake this species of fish is considerably dwarfed.

Pumpkinseeds (Table II) were less common than rock bass, but the differences in number by day and by night and in the shelters and control regions were about the same. They were very strongly attracted to the brush, but not so much as the rock bass. Almost three fifths of those inhabiting the covers by day deserted them at night, when a marked increase in the always low number occurring on the open shoals was noted. Less than 5 per cent of the 800 pumpkinseeds from the shelters exceeded the minimum legal size (6 inches).

The most interesting item in the data for perch (Table III), as

TABLE II

TOTAL NUMBER, NUMBER PER SEINE HAUL, AND SIZES (TOTAL LENGTHS IN CENTIMETERS) OF ROCK BASS AND PUMPKINSEED SUNFISH TAKEN IN BRUSH SHELTERS AND CONTROL AREAS BY DAY AND BY NIGHT IN DOUGLAS LAKE IN 1937 AND 1938

Place, date, and number of hauls	Sizes of fish and hauls	Rock bass				Pumpkinseed			
		Shelters		Controls		Shelters		Controls	
		Day	Night	Day	Night	Day	Night	Day	Night
Grapevine Point, 1937	Min. size	2.2	3.0	2.5	...	2.5	5.2	9.0	10.5
	No. of hauls	9.4	8.6	5.9	...	10.5	10.8	11.7	12.5
	Shelters: Day, 33	Mode size	9-10	6-7?	2-3?	...	10-11	10-11?	?
	Night, 3	Max. size	21.2	16.0	12.4	...	20.0	16.0	17.0
	Controls: Day, 21	No. of fish	1349	74	9	...	221	23	17
	Night, 2	No. per haul	40.7	24.7	0.4	...	6.7	7.7	0.8
Grapevine Point, 1938	Min. size	1.4	2.3	3.0	2.4	2.6	3.2	3.0	6.9
	No. of hauls	Ave. size	10.1	6.6	4.8	5.2	9.0	9.3	10.6
	Shelters: Day, 31	Mode size	12-13	6-7	?	3-4?	6-7	6-7	?
	Night, 9	Max. size	24.0	14.6	5.9	13.5	18.0	18.4	14.5
	Controls: Day, 19	No. of fish	1476	74	3	20	279	24	8
	Night, 4	No. per haul	47.6	8.2	0.2	5.0	9.0	2.7	0.4
North Fishtail Bay, 1938	Min. size	2.5	3.2	4.6	3.7	3.5	3.0	10.0	6.0
	No. of hauls	Ave. size	11.1	10.4	6.5	7.0	7.7	7.5	13.8
	Shelters: Day, 12	Mode size	7-8	?	6-7	7-8	6-7	6-7?	?
	Night, 3	Max. size	23.1	17.1	12.8	9.0	18.9	16.5	16.9
	Controls: Day, 3	No. of fish	364	8	2	6	243	20	8
	Night, 1	No. per haul	30.3	2.7	0.7	6.0	2.3	6.7	2.7
Combined data	Min. size	1.4	2.3	2.5	2.4	2.5	3.0	3.0	6.0
	No. of hauls	Ave. size	9.9	7.7	5.8	5.6	9.0	9.3	12.0
	Shelters: Day, 76	Mode size	9-10	6-7	6-7?	3-4?	6-7	6-7	?
	Night, 15	Max. size	24.0	17.1	12.8	13.5	20.0	18.4	17.0
	Controls: Day, 43	No. of fish	3189	156	14	26	743	67	33
	Night, 7	No. per haul	42.0	10.4	0.3	3.7	9.8	4.5	0.8

contrasted with the information on the rock bass, is their increased abundance on the shoals at night, particularly in the control areas. Here they were indicated to be 24.9 times as numerous by night as by day. About the shelters they were taken 2.6 times more frequently at night. The shelters proved the more attractive in daylight, when the abundance in the brush was found to be 4.2 times that in the open. At night, in contrast, the number of fish in the shelters was less than half that in the control areas. Obviously the perch which abound in the offshore weed beds in Douglas Lake tend to move to the shoals at night, and largely desert the shallows during the day, especially where there is no cover. The perch, taken by day around the brush constructions averaged somewhat larger than those

TABLE III

TOTAL NUMBER, NUMBER PER SEINE HAUL, AND SIZES (TOTAL LENGTHS IN CENTIMETERS) OF PERCH AND SMALL-MOUTHED BASS TAKEN IN BRUSH SHELTERS AND CONTROL AREAS BY DAY AND BY NIGHT IN DOUGLAS LAKE IN 1937 AND 1938

Place, date, and number of hauls	Sizes of fish and hauls	Perch				Small-mouthed bass			
		Shelters		Controls		Shelters		Controls	
		Day	Night	Day	Night	Day	Night	Day	Night
Grapevine Point, 1937	Min. size	3.5	4.5	3.5	4.2	1.4	5.2	4.0	4.5
No. of hauls	Ave. size	11.3	9.3	11.3	9.7	9.5	13.4	7.8	6.3
Shelters: Day, 33	Mode size	13-14	9-10	4-5	4-5?	6-7	13-14?	5-6	?
Night, 3	Max. size	18.5	19.0	18.0	14.3	22.5	16.2	16.0	12.0
Controls: Day, 21	No. of fish	388	112	179	21	143	8	65	5
Night, 2	No. per haul	11.8	37.2	8.5	10.5	4.3	2.7	3.1	2.5
Grapevine Point, 1938	Min. size	2.4	3.0	4.1	4.2	4.0	4.6	4.5	4.1
No. of hauls	Ave. size	12.0	10.1	9.3	9.9	9.6	11.5	10.0	10.9
Shelters: Day, 31	Mode size	11-12	9-10	?	9-10	6-7	4-6	6-7	?
Night, 9	Max. size	19.7	19.5	13.5	14.2	29.3	39.2	36.3	15.4
Controls: Day, 19	No. of fish	813	548	6	584	106	12	38	5
Night, 4	No. per haul	26.2	60.9	0.3	146.0	3.4	1.3	2.0	1.3
North Fishtail Bay, 1938	Min. size	3.5	7.5	5.0	4.5	4.2	4.9	4.2	5.0
No. of hauls	Ave. size	10.7	11.2	5.0	9.0	7.9	5.9	6.2	6.2
Shelters: Day, 12	Mode size	12-13	9-10?	?	5-6	6-7	5-6?	6-7	?
Night, 3	Max. size	15.7	15.4	5.0	14.3	24.0	7.0	12.8	6.5
Controls: Day, 3	No. of fish	171	32	1	125	50	7	23	3
Night, 1	No. per haul	14.3	10.7	0.3	125.0	4.2	2.3	7.7	3.0
Combined data	Min. size	2.4	3.0	3.5	4.2	1.4	4.6	4.0	4.1
No. of hauls	Ave. size	11.6	10.0	11.2	9.5	9.3	10.6	8.2	8.0
Shelters: Day, 76	Mode size	11-12	9-10	4-5	9-10	6-7	5-6?	6-7	?
Night, 15	Max. size	19.7	19.5	18.0	14.3	29.3	39.2	36.3	15.4
Controls: Day, 43	No. of fish	1372	692	186	730	299	27	126	13
Night, 7	No. per haul	18.1	46.1	4.3	107.1	3.9	1.8	2.9	1.9

taken at night, and the same relation held for the control areas, except at one day seining, when a school of small perch was secured. Almost 3 per cent of the perch seined about the brush were of legal size (6 inches), but it should be recalled that the perch in Douglas Lake are markedly dwarfed (Weller, 1938).

Small-mouthed bass (Table III) were not taken in the shelters as commonly as the three species already mentioned and were not much more numerous in the brush than on the open shoals. In both areas they were seined even less frequently at night than by day. Only 2 of the 326 small-mouthed bass seined from the shelters were more than 10 inches long.

Large-mouthed bass were taken in even smaller numbers, but

they revealed a greater preference for the shelters. Of the 102 seined 95 were from the brush, 81 by day and 14 by night; 7 were taken in the control areas, 5 by day and 2 by night. The numbers per seine haul under these four conditions were 1, 1, 0.1, and 0.3, respectively. None of legal size were caught.

It may be concluded that great changes occur from day to night in the fish populations around the shelters and on the unprotected shoals. We can only wonder where the young and the half-grown fish go when they desert the cover. If the legal-sized fish of these species show as much fluctuation in their habitats, is it surprising that fishermen often complain of not being able to catch them? Most assuredly little is known of the movements or the habits of our game fishes.

THE VALUE OF FERTILIZING SHELTERS

To learn whether fish congregate more heavily in shelters that are fertilized two burlap sacks full of barnyard manure were added to shelter 1 and one sack was added to each of shelters 4, 7, 8, and 9 on July 21, 1937, and again on July 15, 1938. Shelters 2, 3, and 10, serving as controls, were not fertilized. These structures, all located

TABLE IV

FISH TAKEN PER SEINE HAUL IN THE FERTILIZED AND UNFERTILIZED
SHELTERS IN DOUGLAS LAKE IN 1937 AND 1938

<i>Species of fish</i>	<i>In fertilized shelters (41 hauls)</i>	<i>In unfertilized shelters (25 hauls)</i>
Game Fishes		
Rock bass	50.8	38.2
Yellow perch	28.7	25.9
Pumpkinseed	8.9	6.8
Small-mouthed bass	3.7	3.8
Large-mouthed bass	0.6	0.4
Bluegill		0.1
Northern pike	0.1	...
Total, game fishes	92.8	75.2
Coarse Fishes		
White sucker	1.6	3.8
Brown bullhead	0.1	0.1
Total, forage fishes	11.4	12.2
Grand total	105.9	91.3

at Grapevine Point, were described in the previous report (Rodeheffer, 1939).

In 1937 filamentous algae grew in profusion on the recently placed fertilized shelters. There were some on the unfertilized covers, but not so many. In 1938 no algal growth was noticeable on any of the shelters. A quantitative study (unpublished) has been made by Mr. O. W. Young on the organic growths on the brush of the fertilized and the unfertilized shelters.

The results of the experiment (Table IV) are not conclusive, though the fish population seemed to be somewhat greater in the fertilized shelters. The fish which most consistently inhabited the brush shelters and which seemed to have a preference for the fertilized ones were rock bass and pumpkinseeds. It was not determined whether the fish in the fertilized shelters showed an increased rate of growth or, indeed, whether individual fish inhabit a given shelter continuously enough to allow a test of the effects of the fertilizer on their growth.

SUMMARY

The evidence of the second summer's study of brush shelters in Douglas Lake supports the views that:

1. Young and half-grown fish of certain species seek the protection of brush shelters, especially during the day.
2. Shelters are repopulated as fish inhabiting them are removed.
3. The fish population about the shelters, as well as on the open shoals, is subject to great individual changes, which need to be considered in checking their use of the shelters.
4. Fertilizing shelters with barnyard manure, although appearing to be of some value in attracting certain species of fish, may not prove effective enough to justify the cost.

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LIST OF SCIENTIFIC AND COMMON NAMES OF FISHES
MENTIONED IN THIS REPORT

<i>Catostomus c. commersonnii</i>	Common white sucker
<i>Notropis cornutus frontalis</i>	Northern common shiner
<i>Notropis h. hudsonius</i>	Great Lakes spot-tailed shiner
<i>Notropis deliciosus stramineus</i>	Northern sand shiner
<i>Hyborhynchus notatus</i>	Blunt-nosed minnow
<i>Ameiurus n. nebulosus</i>	Northern brown bullhead
<i>Esox lucius</i>	Northern pike
<i>Percopsis omiscomaycus</i>	Trout-perch
<i>Perca flavescens</i>	Yellow perch
<i>Percina caprodes semifasciata</i>	Northern log perch
<i>Boleosoma n. nigrum</i>	Central Johnny darter
<i>Poecilichthys exilis</i>	Iowa darter
<i>Micropterus d. dolomieu</i>	Northern small-mouthed bass
<i>Huro salmoides</i>	Large-mouthed bass
<i>Lepomis macrochirus</i>	Bluegill
<i>Lepomis gibbosus</i>	Pumpkinseed
<i>Ambloplites rupestris</i>	Rock bass
<i>Cottus bairdii</i>	Northern muddler

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LARGER LAND SHELLS FROM PINE WOODS IN NORTHERN MICHIGAN

HENRY VAN DER SCHALIE

DURING the summer of 1938 I was given an opportunity¹ to collect land shells in areas of northern Michigan which hitherto have not been carefully surveyed. My wife, who is somewhat conversant with ecological botany, accompanied me on the trip. In the course of this work we found that the larger species of land shells were not present in most regions where pine predominates. This is not a new discovery, but is in agreement with the experience of many collectors who have worked in eastern United States.

It is striking that so few references to this condition have been made in our conchological literature. Three definite statements were noted, however. A. G. Wetherby (1880, p. 37) published the following observation in regard to collections made twenty miles north of Beaumont, Texas: "At this locality, where any fragment of bark, any chip, or any log of other timber was found to be inhabited by the mollusks, the pine logs were invariably barren; and such I have observed to be the case in Tennessee, Kentucky and North Carolina; and the rarity of land shells in forests, almost or exclusively pine, is a fact well known." Victor Sterki (1892, p. 118) took issue with Wetherby's statement and cited from his own experience instances of the finding of land shells in Switzerland, where they are abundant in pine forests. H. A. Pilsbry (1892, p. 118) came to the defense of Wetherby and pointed out that in eastern United States: "We have always found that land shells are rare in pine woods." To bring this matter nearer our Michigan region, Bryant Walker (1902, p. 1955) wrote: "Coniferous forests are usually quite barren of molluscan life. An open hardwood forest in a limestone region is the ideal hunting ground."

In view of these statements we were greatly surprised to find in the summer of 1938 a remarkably rich molluscan fauna in a coniferous

¹ An expedition made possible by a grant from the H. H. Rackham School of Graduate Studies.

area in the northwestern portion of the peninsula lying between Little Bay de Noc and Big Bay de Noc, Delta County, Michigan. At this station the vegetation consisted largely of jack pine, with a few scattered Norway pine, spruce, red oak, and aspen. When we first entered the zone we felt that because of the preponderance of conifers it would be impossible to obtain land shells. Nevertheless, the effort to collect was well repaid, as is evidenced by the following list of species taken at this station.

<i>Species</i>	<i>No. of specimens</i>	<i>Species</i>	<i>No. of specimens</i>
<i>Polygyra albolabris</i> (Say)....	12	<i>Zonitoides arboreus</i> (Say)....	5
<i>Polygyra fraterna</i> (Say).....	14	<i>Strobilops labyrinthica</i> (Say)...	1
<i>Euconulus fulvus</i> (Müller)...	7	<i>Retinella indentata</i> (Say)....	1
<i>Euconulus chersinus</i> (Say)...	4	<i>Pallifera dorsalis</i> (Binney) ...	1
<i>Gonyodiscus cronkhitei</i> cats-			
killensis Pilsbry	6		

To find a satisfactory explanation for this apparent anomaly is not simple. Observations at approximately one hundred stations established during the course of the summer's work lead us to believe that in this particular area there is a marked departure from the usual correlation of the land-shell fauna, the geology, and the vegetation.

Geologically the station is situated in a limestone region which occupies a broad zone along the north shore of Lake Michigan. A limestone cliff of Ordovician age and belonging to the Cincinnati series forms the characteristic bluffs along the west side of this peninsula. It is natural, then, for land shells to be abundant here. Pine would not normally be expected, however, in such a prominent limestone belt. In an effort to account for the presence of this jack pine investigators who have been interested in the plant ecology of northern Michigan for some years were consulted. Unfortunately, they had not studied this region, and could give no clue to the solution of the problem.

M. L. Fernald (1919, p. 52) has shown that jack pine (*Pinus Banksiana*) is invariably associated with acid soils: "These facts and many scores of monotonously similar ones which the writer refrains from merely piling up are sufficient evidence that the Banksian pine is a pronounced *oxylrophyte*." If this is true — and there is every reason to believe that it is — the presence of jack pine in the

limestone region under consideration would indicate that there is a marked difference in the alkalinity of the surface soil and its limestone substratum. On the other hand, the occurrence of larger land shells is perhaps an equally important indicator of an alkaline surface soil. The exact relationships of both the mollusks and the jack pine to the soils in this region are consequently much in need of further investigation.

As a rule, limestone, hardwoods, and land shells are correlated in nature. Here is a case in which the presence of larger land shells is in agreement with the underlying soil conditions, but is inconsistent with the vegetation. Apparently, in limestone areas the vegetation may vary without materially affecting the molluscan life. This leads us to suspect that in his report on the land mollusca of Cheboygan County Allan Archer may have failed to take into account the fact that much of Cheboygan County is in a limestone belt. The geological factor may have been more important in explaining the presence of the five species of land shells he reports from "pine woods" than he may have realized. In view of this we should not accept without further study his statement (1936, pp. 1-2) that "The vegetation appears to exercise a more powerfully modifying influence on the assemblages of mollusks than does the soil."

In conclusion, we believe that the contentions of earlier workers, that coniferous forests in eastern United States are usually barren of molluscan life, are in general valid. In regions such as northern Michigan, however, where the vegetation may not always be in agreement with the geological conditions of an area, changes in the fauna may appear which represent a marked variation from what might normally be expected within the vegetative cover. As yet but little is known about the ecology of many of our land shells, so that we can hardly do more than call attention to the conditions observed.

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